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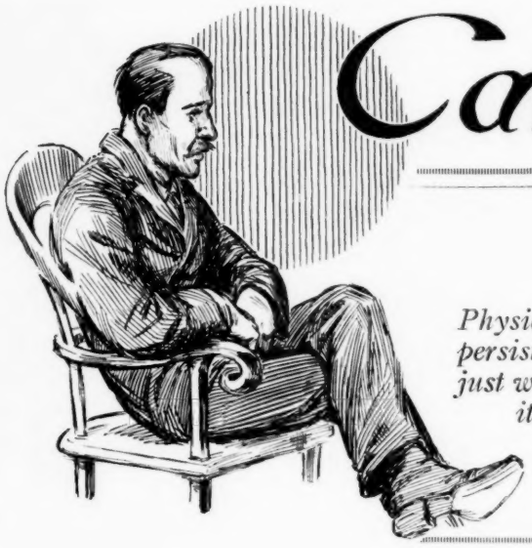


Candid Chats

Inertia

Physicists will give you various definitions of inertia, and if you persist in seeking to learn you may finally get a good idea of just what inertia is—or is not. As applied to a person, however, it can be very simply defined—inertia is what prevents a man from starting when stopped or from stopping when he has started in a particular direction.

TO bring the thought home, because it is and always will be a live issue, take that crankpin that warmed up the other day and that you cooled off so admirably and still "kept her turning over." It is running cool now and has been doing so for a week. You know full well that the pin is cut up and the brasses need scraping, but by running with a knock just faintly audible and with ample lubrication you carry the load and no one knows the difference. Yet every night when you shut down there is an excellent opportunity for some good mechanic, perhaps yourself, to get busy with a scraper and dead smooth file, and put that pin and the brasses in good running condition. Doing it now would prevent a machine-shop bill later. But no. Day after day goes by, and every little knock added to what you have got makes just a little knock more. Moreover, some knocks have an echo that reaches all the way to the general manager's office, and other things knock besides cranks. For instance, a knocker knocks, and if your virtues are not so dominating that they offset the knocks, both deserved and otherwise, then perchance you receive a polite invitation to take a permanent vacation.

Now what was the combination of circumstances and forces that caused you to refrain from giving that poor crankpin a square deal? Simply *inertia*—your inability to start when stopped.

This is one kind of inertia—a bad kind—but there is another which is a good kind, and perhaps, instead of the foregoing, the following better applies to you. On taking hold of your new job you found things in a sad plight; all the engine-room ailments from a leaking expansion joint down to a condenser with tubes sorely in need of repacking. You pitched in, right away, clear up to the elbows and dug. You tactfully educated the firemen into the technique of firing less coal and making more steam. You enlisted the help of everyone available who could grab dollars by the scruff of their necks and jam them into your employer's pocket. You even ordered new supplies and evaporated down to dryness a buying talk for every order—just to overcome the natural conservatism of the purchasing agent and incidentally to get the grade of goods ordered. After several months you had an efficient plant, with every unit ready to buck the peak load at any instant. Then one fine day the central-station shark cornered the general manager and in self-defense he called you up on the carpet. You talked facts and figures to that central-station man until you convinced him that you could produce power as economically as his station without the necessity of having to sell said power at a profit. The session over, you returned to your engine room without leaving a trail of grease behind you, only a good impression, and the central-station engineer went searching for smoking chimneys and exhaust steam.

Analyzing it, what was it that kept you going right up to your acquaintance with the carpet? Simply inertia. Your ability to keep going when once started.

So inertia may be either good or bad. If you are a stationary engineer, dynamically speaking, inertia will assist you in maintaining the "now-I-lay-me-down-to-sleep" attitude; but if you are a live-wire engineer and a connoisseur of what is what in modern power-plant practice, then inertia will reinforce your job and incidentally the pay envelope.

Contributed by E. HURST, *Boston, Mass.*

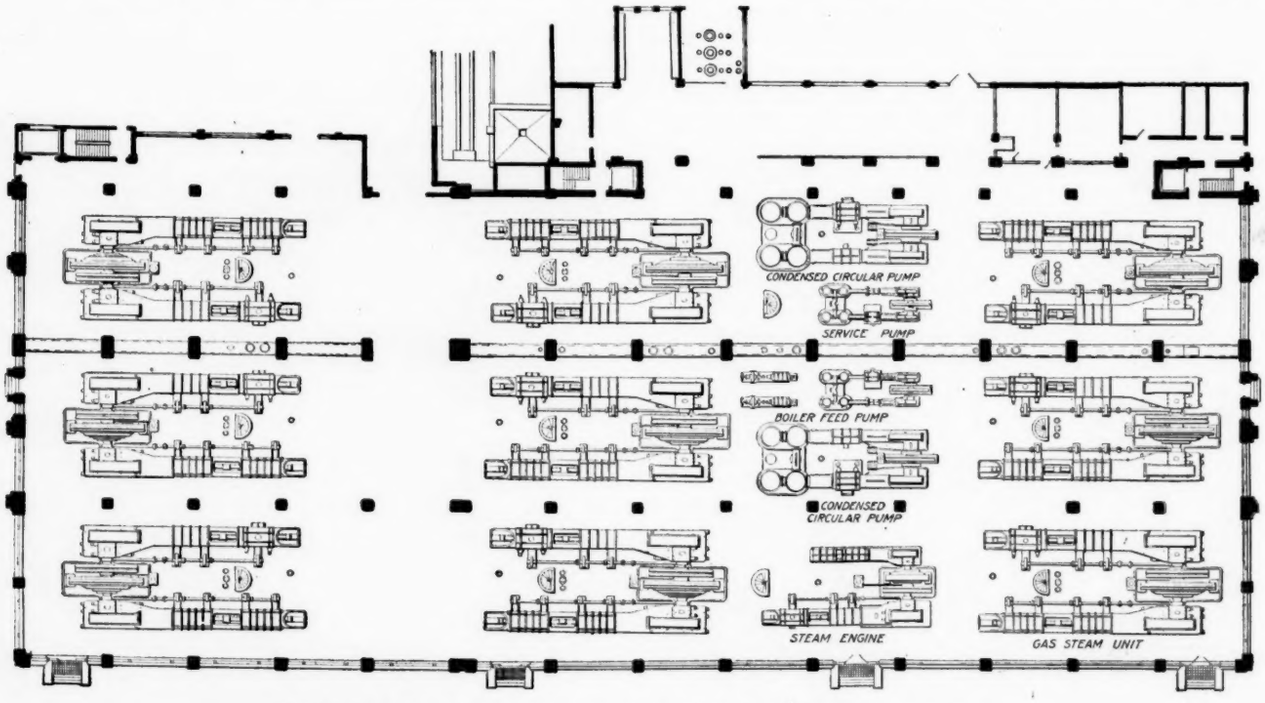
The Ford Engine Room

By Thomas Wilson

SYNOPSIS—A detail description of the composite gas-steam engine standard in Ford plants, giving weights, dimensions, the design of the valve gear and governor control, and an outline of the auxiliary equipment. An article in the Nov. 21, 1916, issue described the schematic layout.

Three years ago the Ford power plant consisted of two gas-engine units aggregating 6,500 hp. At that time these machines supplied only a portion of the load, and the rapidly increasing output from the shops demanded a power plant of much greater magnitude with provisions for additions to the generating capacity. A new power-plant building was started in 1914 and now houses the present equipment. It is a handsome structure, 150x250 ft. in plan, made up of red-faced brick with concrete trimmings, metal window sash and doors painted green, and in accordance with Ford construction a wall area three-quarters glass. A photograph of the building was printed in *Power* of Nov. 21, 1916, in connection with a description of the general scheme of the gas-steam plant. The length of the building is along Woodward Ave., and much of the first floor, which is devoted to the engine room, is visible from the street. Extending 50 ft. back from the front wall the building is one story high, rising 35 ft. above the street. The rear portion rises to three stories, the second being a mezzanine floor containing the main pipe headers, forced draft fans, ash handling equipment, feed-water heaters, etc. The third story houses the boiler room and above are pent houses inclosing the coal-handling machinery. The elevation of this section is 113 ft. This arrangement of the power plant equipment necessitated unusually heavy steelwork weighing some 5200 tons or the equivalent of the structural steel needed to build a modern 20-story skyscraper.

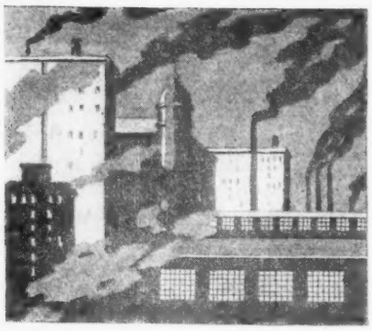
The present engine room has space for six generating units, the pumping machinery for the plant, offices for the engineer and his staff and an immense direct-current switchboard. A 150-ft. extension to the engine room is now under way, which will house three additional composite gas-steam generating units, bringing up the capacity of the plant to 54,500 hp. The engine room will then be 150 ft. wide and 400 ft. long. With walls and columns faced with white enamel brick, other surfaces painted white, and a floor of unglazed vitreous tile, the interior presents an unusually attractive appearance. Due to great size the machinery is imposing and with its black paint and highly polished trimmings stands out to advantage against the white backgrounds. The units are liberally spaced, being arranged three abreast across the room and in line longitudinally. Lining up with the building columns and supplying the various units from the basement, the piping is inconspicuous. In addition much of the valve gear is beneath the floor, so that the engine room is free and clear and accessible to three 50-ton cranes, which have parallel runways extending the full length of the building. At the juncture of the new and older sections a railway track will run across the engine room to facilitate handling of heavy machinery.

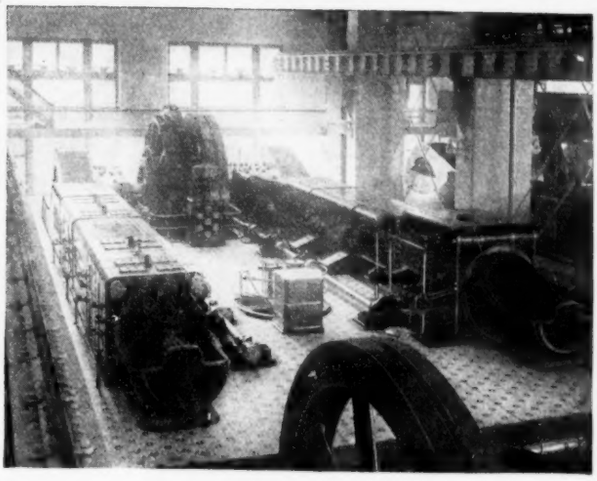


PLAN VIEW OF ENGINE ROOM INCLUDING PROPOSED ADDITION

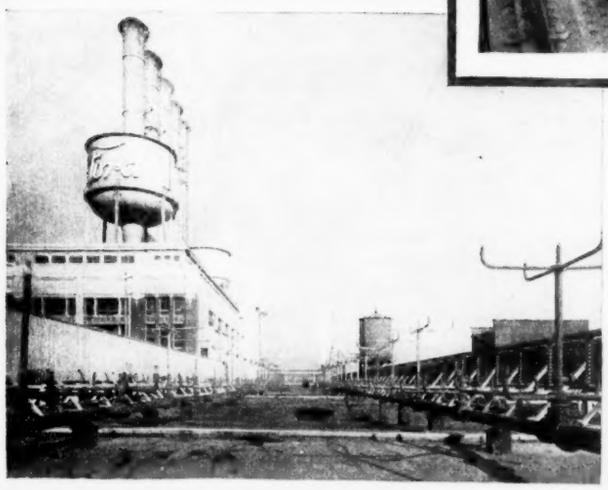
As stated in the previous article, the standard generating unit is a composite gas-steam engine rated at 6,000 i.hp., the gas side having tandem cylinders 42x72 in. and the steam side tandem-compound cylinders 36 and 68 by 72 in. Between the two engines are mounted a 100-ton flywheel and a 4,000-kw. 250-volt direct-current generator, the latter being of unusual size owing to a speed of 80 r.p.m. The approximate weight of the unit

SOME VIEWS AROUND THE FORD PLANT

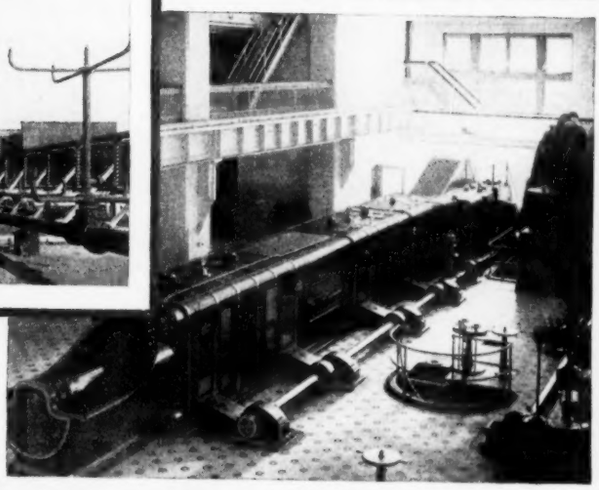




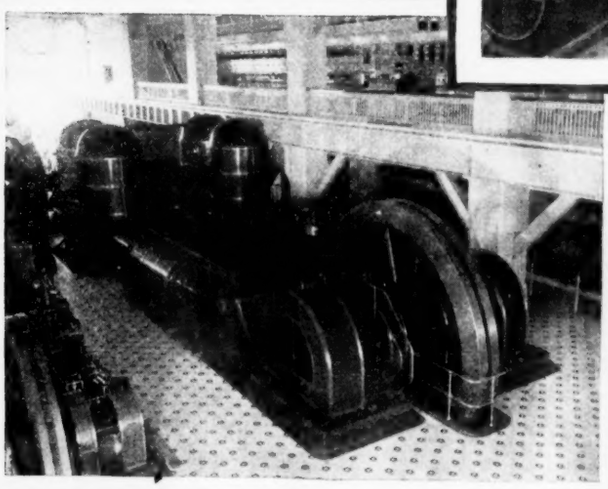
COMPOSITE GAS-STEAM UNIT



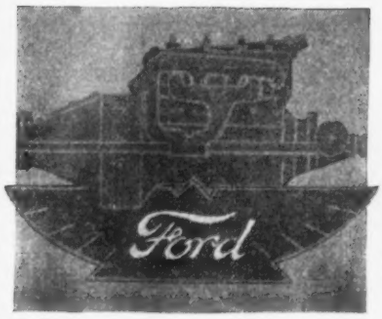
SPRAY POND ON ROOF



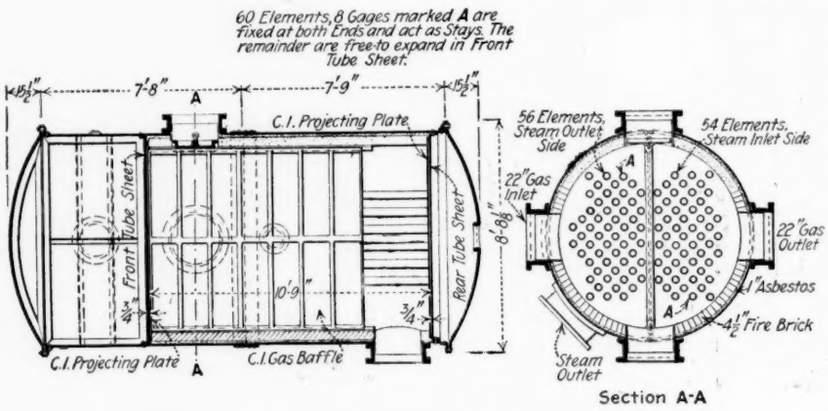
LAYSHAFT SIDE OF GAS ENGINE



CRANK-AND-FLYWHEEL CIRCULATING PUMP



is 1,700,000 lb., the steam engine weighing 700,000 lb., the gas engine 600,000 lb. and the generator and flywheel 200,000 lb. each. Per kilowatt of rating, the total weight reduces to 425 lb. Dividing the rating of 6,000 hp. equally between the steam and gas engines, the former weighs 233 and the latter 200 lb. per horsepower. The bed on the steam side weighs 150,000 lb. and the gas-


60 Elements, 8 Gages marked A are fixed at both Ends and act as Stays. The remainder are free to expand in Front Tube Sheet.
7'-8"
7'-9"
C.I. Projecting Plate
Front Tube Sheet
Rear Tube Sheet
10'-9"
C.I. Projecting Plate
C.I. Gas Baffle
56 Elements, Steam Outlet Side
54 Elements, Steam Inlet Side
22" Gas Inlet
22" Gas Outlet
1" Asbestos
4½" Fire Brick
Steam Outlet
Section A-A

SECTIONAL VIEWS OF SUPERHEATING RECEIVER

engine bed 140,000 lb. The crankshaft, which is 25 ft. 2 in. long, 31 in. diameter at the bearings and 34 in. for the flywheel, weighs 72,000 lb.; the crank disk, 28,000 lb.; and the connecting-rod with boxes, 10,000 lb. Up to the cylinders the designs are the same on either side. The gas-engine piston rods weigh 14,000 lb. and each piston 8,500 lb. The steam-engine piston rods weigh 10,300 lb. and the main crosshead on either engine, complete with shoes, pin and box, 6,600 lb. Over all the composite unit measures 32 ft. wide by 72 ft. long, occupying a floor area of 2,304 sq.ft. This reduces to 0.384 sq.ft. per horsepower of rating, or 0.576 sq.ft. per kilowatt.

It may be of interest that the generator required more than five tons of copper in its construction—1½ tons in an armature measuring 15.5 ft. in diameter and weighing 85,000 lb., the same quantity in the bus rings, interpole, series and shunt fields, and over two tons in a commutator having a diameter of 9.5 ft. The generator extends 14.5 ft. above the floor and 11 ft. underneath. It is of the commutating-pole type with compound fields, and at a speed of 80 r.p.m. is rated at 4,000 kw. The various parts were furnished by the Crocker-Wheeler Co., but the machines were assembled and tested in their present location. The gas-steam engine was made by the Hooven-Owens-Rentschler Co., under designs furnished by the Ford Motor Co.

As will be apparent from the illustrations, the two sides of the composite engine have been made to look as nearly alike as possible. The crank ends, the distance pieces, the tail-rod supports, the main bed and the housings are practically the same, and with a layshaft on either side to operate the valve gear, the resemblance is close. The beds of either engine are the only parts anchored tightly to the foundation; the other weight-bearing elements rest on sole plates so that they have freedom to come and go with changes in temperature. Four 6-in. bolts running the length of the gas engine tie the main bearings and the cylinders together, holding the different parts in their relative positions and throwing all tension strain on steel members.

Owing to the high steam temperature, 600 deg., the high-pressure cylinder of the steam engine has poppet valves, located in the bottom of the cylinder, and on the low-pressure end Corliss valves of standard type. The layshaft is driven by spiral gears from the mainshaft and is divided by solid couplings, allowance for expansion being made at the eccentrics so that alignment with the valve gear will be preserved. At each end of the high-pressure cylinder there are two eccentrics on the layshaft, one for the steam valve and the other for the exhaust. Each eccentric operates a bell crank underneath the floor, the opposing end of the bell crank being connected through a reach rod to a lever communicating with a wiper cam through a latch controlled by the governor. The cam opens a spring-loaded poppet valve downward, slamming of the valve when seating being prevented by a dashpot. For the low-pressure cylinder there are two eccentrics on the layshaft, one operating both steam valves through a bell crank, a vertical rod connecting with an arm on the valve stem and a reach rod to the valve gear on the opposite end of the cylinder. For the exhaust valves a similar connection from an eccentric-operated bell crank is made to a double bell crank or wristplate mounted on the cylinder, a reach rod extending in either direction to an arm on the exhaust-valve stem.

The high-pressure cylinder has a 12-in. steam connection and 8-in. connections to the jacket, receiving the exhaust from the gas engine. It contains a built-up piston traveling at 960 ft. per min. In the low-pressure cylinder the heads have been made to conform to the shape of the piston so that the clearance is unusually small. The piston rod, 13 in. diameter, with an 8½-in. bore, is made up of two pieces, each approximately 20 ft. long, joined together at the intermediate crosshead. The latter is of the split type clamped to the rod and runs in circular ways bored to a radius of 25 in. The main crosshead only has shoes top and bottom. Adjustment is made by eccentric bushings. Both cylinders are covered with magnesia and lagged with planished iron bound by polished metal bands. This lagging continues over the joints between the distance piece and the cylinders, so that the external section is practically uniform throughout. The engine is entirely surrounded by a cast-iron cove 2 in. high that prevents oil running down on the foundation and joins neatly with the tile floor.

The gas engine has two double-acting cylinders, each made up in three pieces consisting of two head housings and the barrel. Circulation of the cooling water is through the heads and housings at each end to the barrel and thence to the overflow. Thus the coldest water goes to the heads, where it is most needed to keep down the temperature of the metal to prevent preignition. In the housings the water is relatively cool, but in the barrel the temperature approaches 200 deg.

Water for cooling the pistons and the rods is taken in at the intermediate crosshead through a telescopic rod which is pivoted below the engine and oscillates with the crosshead. The piston rods are 13 in. diameter and

have a 7½-in. bore. Each rod contains an inner 3-in. tube through which the water flows to the outer end, returning outside the inner tube to the piston, where a dam between the inner tube and the rod forces it to fill the interior of the piston and then continue in the annular space between the rod and inner tube to be discharged through a second telescopic rod on the side of the intermediate crosshead opposite to the admission. Owing to the counterflow of the water, a more uniform temperature is maintained in the rod and excessive strains are prevented. To serve as a cushion preventing water-hammer, air is introduced into the rod.

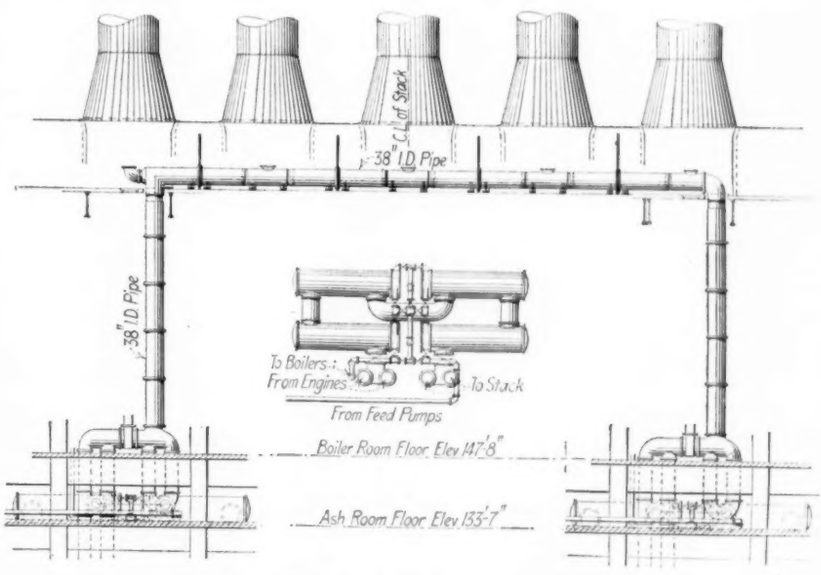
The piston rods are made of chrome-vanadium steel having a tensile strength of 137,000 lb. The pistons are steel castings made with convex surfaces. Under 100 tons' pressure each piston was forced onto the rod against the shoulder and followed up by a nut, which was set up tight and turned off flush. The connecting-rod is an openhearth forging with openings for the boxes machined from the solid metal, while the crank disk is a steel casting, with the pin, which is 20 in. diameter and 15½ in. long, cast integral. As previously explained, the crankshaft is 25 ft. 2 in. long with a diameter of 31 in. in the bearings and 34 in. at the flywheel. On the gas side the bearing is 50 in. long and on the steam side 60 in., as the flywheel is mounted on this side. A solid layshaft, made 8 in. diameter to prevent lag or torsional movement at its far end, 55 ft. 5 in. distant, is driven from the mainshaft by spiral gears, the ratio being 2 to 1. The brackets supporting the layshaft are bolted directly to the cylinders with pin joints in the shaft to preserve alignment of the cams and valve gear. The shaft carries eight hardened steel cams for four inlet and four exhaust valves, one admission and one discharge valve being located at each end of each cylinder and at the bottom of the bore. The valves are of cast iron cast to vanadium-steel stems, each pair of valves being mounted in a cast-steel valve box bolted to the bottom of the housing. The valve box is bushed for the valve-stem guide, making replacement simple and furnishing a seat for the spring closing the valve. An independent water supply to the valve box insures moderately cool valve seats so that neither inlet nor exhaust valves are water-jacketed. Between the valve stem and the cam on the layshaft the working medium is a large cast-iron rocker arm reinforced by a steel tie member. The cam operates on a hardened steel plate at one end of the rocker arm, and at the opposite end an adjustable tappet is interposed between the rocker arm and the valve stem. It is one of the simplest of valve gears and has given excellent satisfaction.

Two force-feed Richardson-Phenix lubricators per cylinder, driven by linkage from the exhaust rocker arm, deliver oil under pressure to the inlet- and exhaust-valve stems, cylinders and piston-rod packing. Other oiling on the unit is effected by gravity from an overhead filter-storage system. As the same oil is used in bearings and cylinders, the force-feed lubricators are filled from the gravity system, so that the oiling is entirely automatic. The present equipment consists of four Peterson power-plant filters each having a filtering capacity of 3,000 gal. per hr. The filters are equipped with heating and cooling coils, automatic water ejectors on the heating and precipitation compartments, wall-type oil-level indicators with high and low electric alarms on the clean-oil and filtering compartment.

Head housings, cylinders, piston-rod water connections and other points are equipped with thermometers. At each main bearing a rider is carried on the shaft in the form of a babbitted block bored for a recording thermometer bulb. The thermometer has an electric-bell connection to sound a warning when the bearing reaches a certain temperature. A similar scheme is to be carried out on the crank and crosshead pins, thus eliminating to a great extent the human element in detecting hot bearings.

Ignition is of the make-and-break type, a duplicate system being provided on either side of the engine, each being supplied with current from independent storage batteries in either leg of a three-wire system. There are eight igniters per cylinder, two on each side at both ends of the cylinder. Four igniters drawing current from two different sources should insure ignition and by sparking on either side hasten flame propagation in the slow-burning producer gas. From battery to engine the ignition current is conducted through a three-wire system. The neutral is grounded to the frame of the engine, the positive wire leads to one igniter and the negative wire to the other, so that sparking from the two is simultaneous.

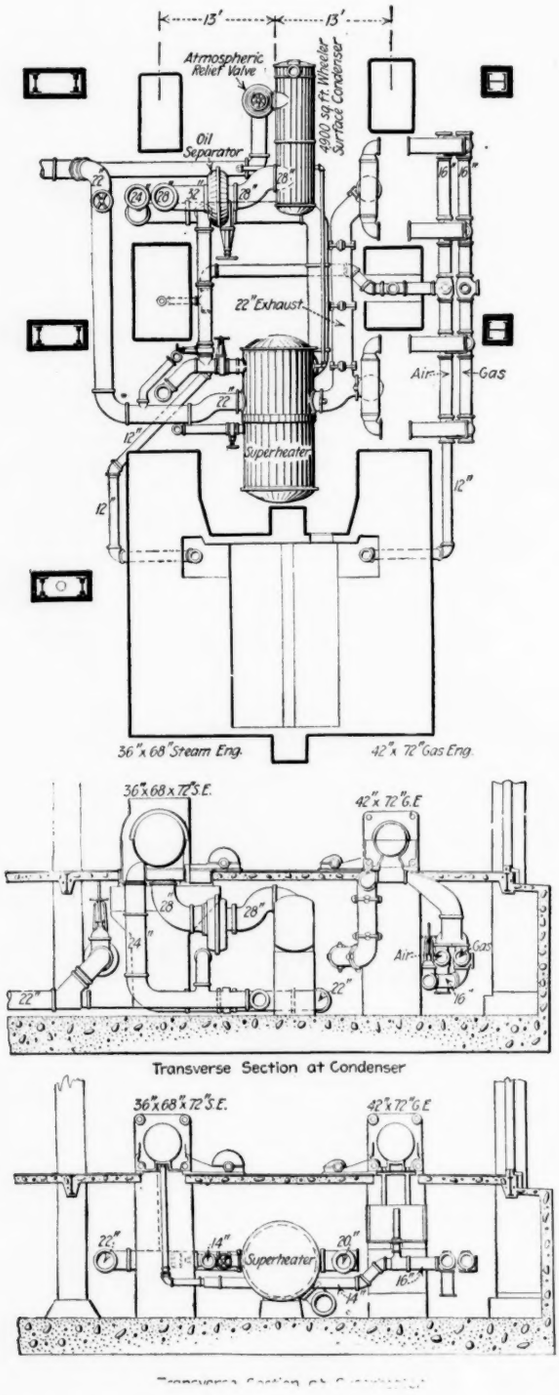
Current is distributed to both sides of the engine in proper sequence by two simple commutating devices or timers mounted on a pedestal and spiral geared to the layshaft. On each brush there is an individual timing device, but the advancing or retarding of each timer as a whole is done at the control stand located between the engines and midway of their length. At the top of the pedestal is a safety governor which rises with the speed and, when a prescribed limit has been reached, breaks mercury contacts and opens the ignition circuits. When



GAS EXHAUST PIPING FROM FEED-WATER HEATERS TO BOILER STACKS

the generator circuit opens, the ignition current is automatically interrupted by a switch functioning with the circuit-breaker, so that the production of power on the gas side will be stopped instantly. Another break in this line may be made by the operator at the control board.

At the igniter the break is made electromagnetically. A solenoid with a plunger attached to the movable elec-



PLAN AND ELEVATIONS, SHOWING GENERAL ARRANGEMENT AND PIPING OF COMPOSITE UNIT

trode is provided. When the distributor closes the circuit, the current passes through the coil on its way to the gap, pulling up the plunger and breaking the contact by turning the movable electrode. The inductive action of the coil tends to intensify and lengthen the spark.

Regulation of the unit is effected by a Jahns governor mounted on a box base located between the two engines, just in front of the generator. The outer face of this base is used as a gage board, giving all operating data essential to the operation of the unit. The governor is driven from the crankshaft by three independent rope drives. The control rod passes down through the floor to an arm on the cross-shaft, bevel-geared at either end to a shaft running parallel with its respective engine. On the gas side two eccentrics on the governing shaft control the quantity of gas and air, but the control is so designed that no action is taken until the engine exceeds normal speed.

On the steam engine the low-pressure cylinder has the regular Hamilton Corliss cutoff with a vertical rod and arm connecting to the governing shaft. For the poppet valves on the high-pressure cylinder the method is the same in principle.

Elaborate Control Board Used

An interesting feature is the control board, which has handwheels to control ignition, the air and gas mixture and the cooling water to the gas engine; meters to indicate the voltage on either ignition circuit and the load in amperes on the main generator. It also contains an elaborate signaling system, which is duplicated on the switchboard. It consists of white, green, amber and red lights with a push-button opposite each, labeled to indicate the action intended. The white light burns when the unit is running, the green light is a request to raise the load, the amber light calls for a reduction in load and the red light means to shut down. A push-button ringing a bell to call attention to the signal is also provided. In addition to the control board, there are three floor stands—one on the main steam throttle, one on the gas main and the third controlling the atmospheric relief valve on the condenser.

In the previous article mention was made of the superheating receiver located in the basement between the high- and low-pressure cylinders of the steam-engine. The shell, which is 18 ft. long over the bumped heads and 7 ft. 11 in. external diameter, contains 130 Foster superheating elements 2 in. outside diameter and 10 ft. 9 in. long. The elements, or tubes, contain ¾-in. cores so that the steam may be exposed in thin layers to the hot gases from the gas-engine exhaust. Cast-iron fins over the tubes protect the metal and, by giving a greater surface, also help to increase the heat exchange. A cast-iron plate ½ in. thick protects the tube sheets, and firebrick line the shell. In the superheaters for the new addition to the plant it is proposed to use ingot iron tubes and a coating over other exposed metal as a protection against the exhaust gases, although at the high temperatures serious corrosion is not expected.

At normal load it has been figured that 508 lb. of gases per minute leave the cylinders of the gas engine at a temperature of 1,050 deg. F. In the water-jacketed exhaust pipe 200 deg. are lost, so that the gases enter the superheater at a temperature of 850 deg. The drop in the superheater is 300 deg., and with a specific heat computed to be 0.27, the gases leave in the superheater about 41,000 B.t.u. per min. In the 500 lb. of steam passing through the superheater during the same time, there should be about 600,000 B.t.u., the proportion of waste heat thus approximating 7 per cent. The exhaust

gases should add that portion of 82 B.t.u. not lost by radiation to each pound of steam.

The condenser, also located in the basement, is of the Wheeler surface type having 4,900 sq.ft. of surface in 5/8-in. brass tubes, There is an atmospheric relief from the condenser to the gas-engine exhaust pipe, but no bypass to cut out the condenser. An Edwards triplex pump, 18x12-in., driven by a 30-hp. motor, removes the condensate, discharging it to the surge tank. Water for cooling is circulated by either one of two Hamilton crank-and-flywheel pumping engines on the engine room floor. The pump is of the duplex type, having floating plungers 25x48 in. The steam end is a cross-compound engine with cylinders 32&60x48 in. At the mean speed of 27 r.p.m. the pump will deliver 14,700,000 gal. of water per 24 hr. against a head of 125 lb., and at a maximum speed of 35 r.p.m. 19,100,000 gal., the above pressure being required for fire service. Ordinarily, it works against a head of 20 lb.

As the cooling water must be drawn from the city mains, the supply is conserved by means of spray ponds on the roof of a building adjacent to the power plant. The entire roof, which is 72 ft. wide and 800 ft. long, will be utilized. There are now five ponds, each having 216 nozzles guaranteed by the Spray Engineering Co., to cool 4,200 gal. of water per minute 28 deg. from various temperatures and outside weather conditions. Preparations are now under way for three more ponds of the same size. Under a head of 20 lb. the water passes from the ponds down through the condensers and up to the suctions of the circulating pumps. The total head on the delivery side including the drop through the nozzles is 40 lb., giving a friction head of 20 lb. against which the pumps must work. To reduce evaporation and drift, part of the pond water is mixed with the return water from the condensers to reduce the temperature before the water reaches the nozzles. This is accomplished by running a cross-connection from the down line to the pump suctions, a valve in this connection determining the proportion of water bypassing the condensers.

During the colder months a hot-water heating system serving the entire manufacturing plant will absorb the heat from the condenser steam and still allow a vacuum approximating 20 in. on the engines. It is figured that the power and heating loads will practically balance, so that this arrangement should give highly economical results. Although some direct radiation is installed in the office building, much of the heating is done with indirect coils in connection with a hot-blast fan system, with provision for recirculation of air. All radiation has been figured on a basis of water at 150 deg. in zero weather. The water temperature can be lower in moderate weather so that a vacuum approaching the normal 26 in. may be obtained.

In other articles to follow, the boiler room, gas-producer plant and the switchboard will be described in detail and illustrated.

Reconnecting Induction Motors—Rotating Magnetic Field

By A. M. Dudley

SYNOPSIS—The first of a series of articles on rewinding induction motors. This installment gives a general outline of the subject and explains how the rotating magnetic field is produced in an induction motor.

Many induction motors are shipped by the manufacturer, installed by the purchaser, and finish their natural period of usefulness with practically no change, either electrical or mechanical, in the conditions under which they operate. Others encounter various changes, which may arise in a number of ways; as for example, moving a factory from one locality to another, discontinuing an isolated plant to purchase central-station power, raising the voltage on an overloaded distributing system, or the resale of the apparatus to another user.

When such changes take place, they at once give rise to questions regarding the adaptability of the old apparatus to the new conditions. As in other respects, the induction motor is here, also, quite flexible, and in many cases simple readjustments of the windings can be made quickly and cheaply, which permit normal operation under the changed conditions. In other instances the changes are more difficult, and there are some so radical that it is better economy not to attempt them.

There are altogether five characteristics that can be changed; namely, horsepower, cycles, volts, phase and number of poles, the last changing the speed of the motor. The possible number of combinations that can be made changing these one at a time, or two, or three, is so great that it is not possible to provide convenient formulas or diagrams that will be universally applicable. But there are certain general conditions and relations that are concerned in all cases and these can be covered in a broad way and give a basis for the solution of a particular problem. Considered in the order of their desirability the possibilities in the case of changed conditions are: (1) Motor operated under new conditions without change; (2) reconnection of the old windings to meet changed conditions; (3) supplying a complete set of new coils; (4) supplying new sheet-steel laminations and also new coils.

Before passing to the possibility of reconnecting the windings to operate under changed conditions, it is well to consider briefly the fundamental characteristic of the induction motor, which is the rotating magnetic field. With the proper conception of how this field is set up and caused to rotate and its effect upon the windings of the motor as it rotates, it is easier to form an opinion of the possibility of accommodating the motor windings to changed conditions.

It is now generally understood that an electric motor produces torque, or driving effort, by utilizing the effect of a magnetic field upon a wire or wires which are carrying electric current. It is also understood that a mag-

netic field may be produced in an iron circuit by passing an electric current through a coil which surrounds or is interlinked with that iron circuit. The action of producing driving effort in a direct-current motor then becomes very simple. First the magnetic field is set up by passing a direct current through the field coils surrounding the poles. This direct current is drawn from the same source of supply that is to drive the motor. When the magnetic field is set up, another direct current is drawn from the source of supply and caused to flow through the armature coils which lie in the magnetic field just previously set up. The action of the magnetism of the field on the current in the armature wires causes the rotor to develop torque and start to turn.

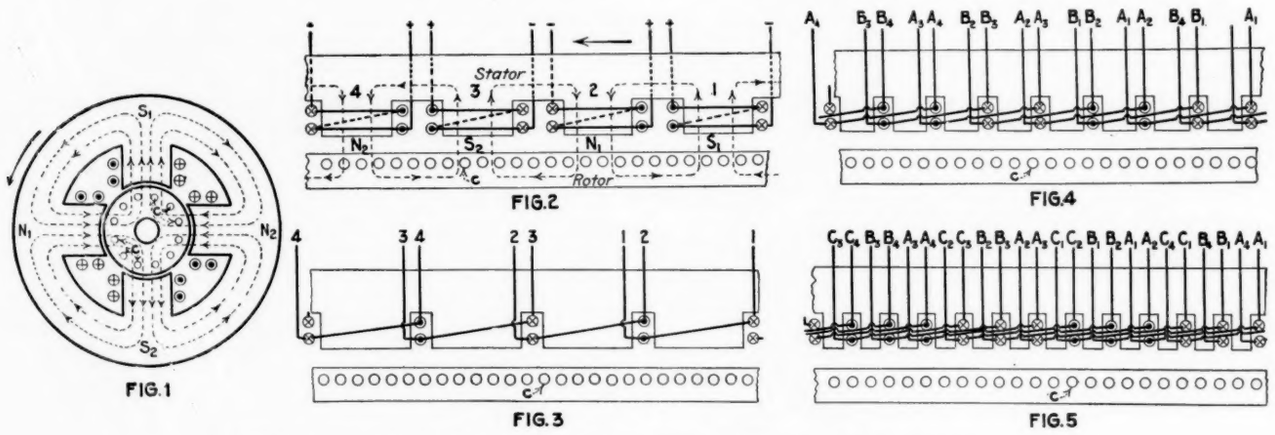
The foregoing is elementary and exactly the thing that happens in the alternating-current motor, but in a little different way. In the direct-current motor just noted, two sets of coils were used. The first set—the field coils—was used to excite the magnetic field; the second set was the armature coils and was used to carry the working current. In the induction motor there is but one set of coils, which must at the same time exercise the two functions of setting up the magnetic field and carrying the working current. This fact is chiefly responsible for the condition in the motor which is called power factor and which is not present in the case of the direct-current motor.

It is worth while to consider as simply as possible the manner in which the magnetic field is set up in the induction motor and the reason it travels around the machine at a relatively high rate of speed.

Long before the days of Tesla and Feraris, it was known that if a magnet was passed over a sheet of copper close to its surface, a force was produced which tended to cause the copper to move in the same direction as the magnet. Although not then so recognized, this was the fundamental principle on which all modern dynamo-electric machines are based. The contribution that Tesla and Feraris made was the discovery that such a moving magnetic field could be set up by an alternating current and need not rely on a permanent magnet or one excited by direct current.

The matter of setting up such a field by alternating current and causing it to move can be shown by a few simple figures. Fig. 1 is a cross-section through a direct-current machine. It shows an outside field yoke with inwardly projecting field poles with a coil around each polepiece through which a direct current is flowing. The usual convention is adopted to show the direction of the field current by marking the conductors with a dot when the current is flowing toward the observer and with a cross when it is flowing away. The armature is shown by the inside circle carrying the conductors C on its periphery; in practice these conductors would be connected to a commutator. The magnetic field itself is represented by the dotted lines passing from one pole into the armature and out through adjacent poles, as indicated by the arrows.

If now, contrary to the usual practice, the machine is suspended by means of the shaft projecting on either side and the armature held from turning by clamping the shaft, it would be possible to take hold of the field frame and rotate it around the armature. Mechanically such a rotation would not interfere with the usual electrical functions of any of the parts of the machine since the brushes would bear on the commutator as usual and move relatively to the polepieces, the only difference being that now the commutator is standing still and the brushes are moving.



FIGS. 1 TO 5. EXPLAIN HOW A ROTATING MAGNETIC FIELD IS PRODUCED

Going a step farther, if the field was driven mechanically at a fair rate of speed around the armature, this inverted direct-current machine would give a very fair representation of what is going on inside an induction motor. So far as the rotating magnetism is concerned, it is just as surely present in the one case as in the other and with just as plainly marked north and south poles. The difference is that in the induction motor the magnetic field alone rotates and the iron core with the windings stands still, while in the case of the inverted direct-current machine described, the iron core and the field coils are going around with the magnetism.

The picture that the foregoing is intended to bring out is that in any running induction motor a well-defined magnetic field is actually rotating in the stator exactly the same as would be the case if we excited a field of equal strength by direct current and rotated it mechanically. This is an easy conception and, once held clearly in mind, explains everything that happens when the frequency is changed or the number of poles or any of the various changes are made that are under consideration in this discussion. The manner of setting up this field by alternating current instead of direct current and making it rotate electrically instead of driving it mechanically is explained in Figs. 2 to 5.

Fig. 2 shows the same machine as Fig. 1 except that it is developed or rolled out flat the better to illustrate the point. Suppose, for example, that it is desired to set up a magnetic field as shown and cause it to travel from right to left in the direction of the arrow. One method of doing this would be to excite the pole marked No. 1 with direct current to produce a south pole as shown; a fraction of a second later No. 1 could be cut off and No. 2 made a south pole; after the same interval of time No. 2 could be cut off and No. 3 excited south; followed, in turn, after the same interval again, by cutting off No. 3 and exciting No. 4. Thus a south pole would have traveled regularly and steadily from right to left as desired. But this is using direct current.

An analysis of what really happened shows that while No. 1 was excited as a south pole, No. 2 might just as well have been excited as a north pole since the magnetism to flow into No. 1 and make it south must flow around and out of No. 2, as shown. This is indicated by the dotted lines, which represent the magnetic field. At this instant, then, coil No. 1 would be excited minus and plus and No. 2 excited plus and minus, as shown. However, the next instant, when No. 2 is to be made a south pole, this excitation would have to be reversed to minus and plus, and an instant later, when No. 3 becomes a south, No. 2 can again be a north and the excitation would again reverse to plus and minus. Consideration of any particular coil in this way shows that each time the field moves forward one pole, the excitation of all the poles changes in direction and consequently each pole might quite as well be excited by alternating current, which in effect is really rapidly reversing direct current.

The Frequency of an Alternating Current

The rapidity of these reversals or the so-called frequency of the alternating current would depend on how rapidly the field was expected to advance a space represented by the distance from center to center of adjacent poles. And this is exactly what happens: If the motor has four poles the field will have to advance four times to make one complete revolution around the motor, and if it is desired that the field shall make 1,800 r.p.m., there will be required $4 \times 1{,}800 = 7{,}200$ reversals. This is readily recognized as the sixty cycles of the commercial alternating-current circuit. Conversely, since the r.p.m. of the motor rotor is nearly that of the magnetic field, if 60-cycle current is available and power is wanted at 1,800 r.p.m. or thereabouts, a four-pole motor is required.

From the foregoing it might appear that single-phase alternating current for excitation is all that is needed, and for this reason Figs. 3, 4 and 5 are shown. Since Fig. 2 is a direct-current structure, the field would progress by jumps and hitches from pole to pole around the machine rather than steadily and evenly; hence, in Fig. 3 the slot between poles is reduced to the size of an armature slot, of which the necessary number are evenly spaced around the machine. Also, for simplicity the field coils are shown gathered into one coil per pole.

In Fig. 3 the step from pole to pole is still rather wide, so that in Fig. 4 coils are introduced halfway in between and these are excited by a second alternating current which is just as much behind the first one in time as it takes the field to travel one-half a pole, and such an arrangement of two alternating currents is called two-phase. Similarly, if desired, three currents could be used, as shown in Fig. 5, and this would represent the well known three-phase arrangement.

From this explanation it must not be gathered that in the case of the two-phase there are two rotating fields and three in the case of three-phase. This would be true if the two currents or three were acting entirely independently, but they are not—they are all trying to excite the same iron circuit and the actual resultant magnetism at any instant is due to the combination. In other words, since one current is ahead or behind the others by a fraction of a pole, the currents in the different phases have different values at any given instant. In the case of three-phase one may be zero, the second be increasing and be equal to one-half its maximum value, and the third be decreasing and be actually at one-half its maximum value. Since these three currents are all acting on the same iron circuit, the magnetic field which actually exists at that instant is due to the resultant of the three currents. Thus the resulting field looks exactly like the field in Fig. 1, which was set up by direct current, and it travels around the stator iron just as did the field in the mechanically rotated direct-current machine.

The Counter-Electromotive Force

Having considered the manner of setting up the field and causing its rotation, there is another action, easily understood, which is perhaps as useful as any in giving a clear idea of how many turns are required in a motor winding under different conditions. This is what is called the generation of the counter-electromotive force. Since the coils of the motor are standing still and the magnetic field is rotating past them and threading through them, there is of necessity a voltage generated in the coils by the rotating field. This is the voltage which is referred to as counter-electromotive force and is in all cases equal to the voltage of the supply line which is applied to the motor, except for a small loss in the motor caused by producing the necessary torque or driving force.

Summing up, it will be seen that the coils on the stator or primary of an induction motor have three distinct functions: They must, first, carry the magnetizing current necessary to set up the rotating magnetic field; they must, second, carry the working current which shall react on the magnetic field and produce mechanical force to drive the rotor; they must, third, generate a voltage practically equal to the line voltage and opposed to the line voltage, so that no more current can be forced through the motor than is necessary to do its work.

With this conception and the fundamental formula for the generation of an electromotive force, it is a simple matter to write expressions showing how the turns in a motor should vary with different line voltages and for different speeds, etc. For example, a motor to operate on 440 volts must have twice as many turns in the coils as the same motor when operating on 220 volts, and a motor operating at 900 r.p.m. in general would require twice as many turns as the same motor when operating at 1,800 r.p.m. These are matters with which the designing engineer is chiefly concerned, but they are sufficiently simple to be borne in mind at all times, and in themselves offer the readiest first-hand answer as to the probable result of operating a given motor under changed conditions.

Care of Water-Tube Boilers

By A. C. McHugh

In many small plants where water-tube boilers are installed, the drums are scaled and the tubes turbined regularly and the loose mud and scale taken from the mud drum, but that is about as far as the cleaning generally goes. In boilers of the Heine type the water-legs should be given the same attention as the tubes or drum. The front leg may be scaled while the caps are off for the tube cleaning, but the back caps should also be removed at least every second or third cleaning to permit a thorough scaling of this portion, as it is surprising how fast the scale will collect there. What is true of the Heine is even of greater importance in the B. & W. type and as it is a disagreeable task, the headers and vertical circulating tubes and nipples are often slighted. But the engineer should always make it a point to see that these parts are free and reasonably clean before the boiler is closed up.

From a safety point of view, the rear vertical circulating tubes and headers are perhaps the most important portion to keep clean, for the circulating tubes are of the same size as the nine or more heating tubes which they supply, the rate of circulation is rapid and they should have as clear a passage as possible. In fact, many tube failures have been caused by an insufficient supply of water being furnished to the lower tubes during a period of heavy overload, as the greater portion was bypassed through the upper tubes thus leaving the lower ones partly dry. To prevent this, attempts have been made to bush the front ends of the upper tubes, retarding the circulation through them and sending a larger supply to the lower ones.

In cleaning the rear circulating tubes, a scraper having a jointed handle is sometimes used; but better results will be obtained through the use of a water turbine cleaner. While it is not impossible to use a steam cleaner for this work, it must be done through the manhole in much the same manner as in the Stirling boilers, while with the use of a water-operated cleaner a man may safely work from inside the drum.

To clean the headers, the caps must be removed and a scraper or bar used through the handholes. About the hardest part to clean, in this type of boiler, is the mud-drum nipples. Although not as important as the circulating tubes, they should be kept reasonably clean.

A boiler that has been cleaned, but has not had the caps removed from the rear headers, should never be closed up until a lamp has been passed from the upper end of each circulating tube, through the tube, header and mud drum nipple, to make sure that they are all clear. In doing this, the writer has often found the headers completely packed with loose scale. Should the boiler be fired up without removing this scale, tube failures would result.

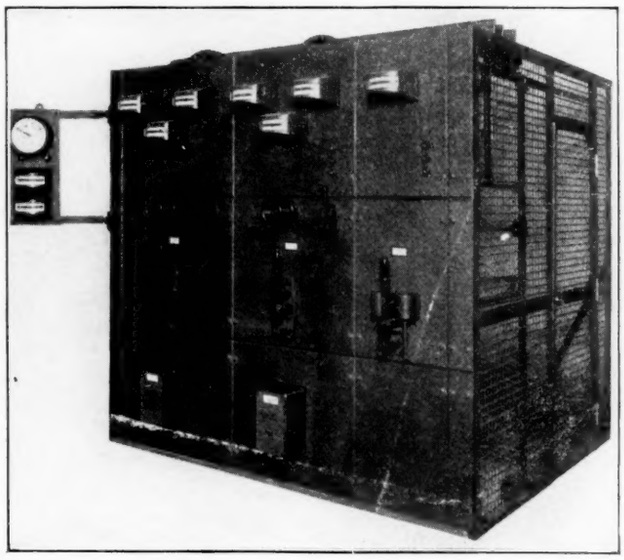
All who have had occasion to test the B. & W. type know that the mud-drum nipples are about as susceptible to leaks as any other point, and it often happens that it is almost impossible to see the nipple because of the deposit of scale that has leaked from them and been allowed to accumulate. This should not be permitted, as the nipples are in a position where soot deposits heavily and forms one of the most destructive corrosive agents when wet. As a result, the deterioration of these nipples is nearly always from the outside. If the exterior of these nipples is thoroughly cleaned and painted with a good heat-resisting boiler paint, it will be easy to detect defective nipples at the next regular cleaning period.

If it is possible to dent a nipple by lightly tapping a blunt-nosed tool held against its side, a new one should be put in. These are more difficult to remove and replace than any other nipple or tube in the B. & W. type of boiler and require the exercise of judgment and care.

In preparing to replace a nipple, first make the following calculation as to the end pull on it: Multiply the boiler pressure by the area of the nipple, then add its share of the weight of the mud drum and water—the total weight divided by the number of nipples. For example: Boiler pressure, 100 lb.; nipples 4 in., equals 12.56 sq.in.; $12.56 \times 100 = 1{,}256$. Adding 35 to 50 lb. for the weight per nipple of the mud drum and water gives about 1,300 lb. to be supported by each nipple. Won't that promote carefulness?

Safety-First Switchboard

Probably in no phase of industrial activity has the safety-first propaganda a more direct application than it has in the electrical industry. Close coöperation between the manufacturers and the large users of electrical machinery has resulted in the development of many devices to safeguard life and property.



DEAD-FRONT SAFETY-FIRST 2300-VOLT SWITCHBOARD

A recent development by the General Electric Co., Schenectady N. Y., along this line is the switchboard shown in the illustration, which embodies several desirable features of safety and convenience and is built for general power and lighting service up to 3,500 volts at 25 to 60 cycles.

All live parts except current and potential receptacles are inaccessible from the front of the board, and the live parts of these receptacles are recessed so that accidental contact with them is difficult.

Disconnecting switches are used between all oil circuit-breakers and busbars and provide convenient and rapid isolation of the breakers from the bus for inspection, changing oil or repairs, without hazard. Instead of the usual

calibrating switches back of the panel, calibrating receptacles are used which permit safe and convenient calibration of the instruments and meters from the front. The insertion of plugs in the calibrating receptacles connects the testing instrument in series with the instrument under test. The board is also equipped with removable fuse receptacles of the screw-plug type, which provide for a replacement of secondary potential transformer fuses from the front of the switchboard without the danger of contact with live parts.

The live parts of the field switches are mounted on slate bases back of the panel and are connected to operating handles on the front of the board by rods and bell cranks. This method of mounting field switches makes it impossible for the switchboard attendant to be injured by the arc or to come in contact with live parts of the switch when operating. Instruments and other adjacent equipment are likewise safe from damage by burning, which sometimes happens with the front of board type.

When switches are required for arc or incandescent circuits, they are of the dead-front plug type. All live parts are back of the panels and cannot be touched from the front. This result is obtained by using two tubular receptacles and a two-point double-break switch plug per pole. The entrance bushings for receptacles are of molded material and extra large in size.

Steam-Engine Troubles—Receivers

By H. Hamkens

SYNOPSIS—This, the third article of the series, considers good and bad design of steam receivers. Receivers are often found that are too small to give good steam distribution and cutoff in the low-pressure cylinder. The large number of accidents due to weak receivers shows that the receiver, its piping and the low-pressure cylinder should be strong enough to withstand boiler pressure.

On compound steam engines trouble may be experienced with the receiver, which is often too small to give a good steam distribution and cutoff in the low-pressure cylinder, is treated as inferior and superfluous, and is made without regard to strength and efficiency. Accidents to receivers are multiplying, and it is about time that they were watched more closely. They should be of ample size—that is, from 1½ to 2 times the piston displacement of the low-pressure cylinder. This ratio should be carried out on cross-compound and tandem compound engines alike. It is a mistaken idea that tandem compound engines do not need a receiver.

The piping to and from the receiver, the receiver itself, and also the low-pressure cylinder should be made strong

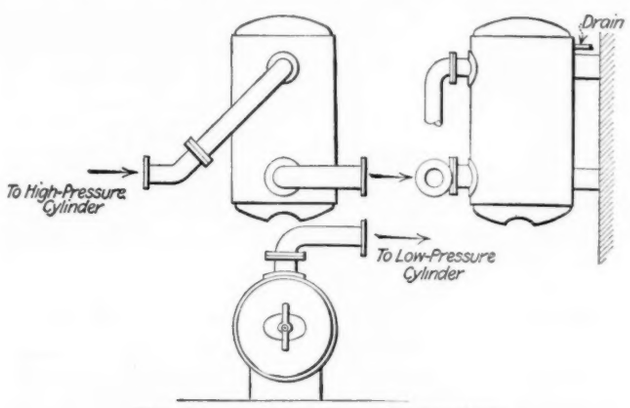


FIG. 33. RECEIVER CONNECTIONS

enough to carry the full boiler pressure—not as a working pressure, but for emergency. The old way of making low-pressure cylinders of light weight and also light receivers and pipe connections is extremely dangerous, for if anything happens to the high-pressure steam valves or their gear to prevent closing of the valves, steam under full pressure will blow into the receiver through the high-pressure exhaust valves when they open. Every receiver should be provided with at least one safety valve—not a small relief valve to indicate when the receiver pressure has reached the danger point, but one

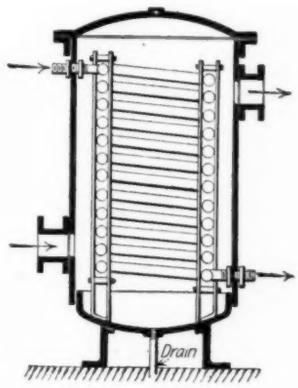


FIG. 34. REHEATER RECEIVER

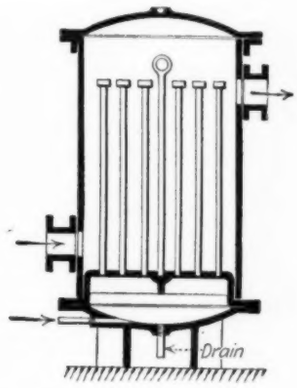


FIG. 35. POOR DESIGN

that has an opening about three-fourths the area of the high-pressure exhaust; or better, it might have two safety valves of the locomotive type, with large pipe connection to the outside of the building.

A vertical receiver with the high-pressure exhaust entering near the bottom and the low-pressure steam pipe leaving at the top is a good arrangement, but there may be occasions when a horizontal receiver would be more convenient. The advantages of the vertical receiver lie in the ease of draining and of reheating, if this be necessary; its disadvantage in the fact that it cannot be located very conveniently, unless there is a basement that affords sufficient headroom under the engine room. If the receiver extends above the floor line it takes up valuable space and is rather unsightly. There are no objections to the horizontal receiver, if well drained.

The arrangement shown in Fig. 33 can be recommended for cross-compound engines. The receiver is located in the basement sufficiently low for the exhaust pipe from the high-pressure cylinder to be connected to a flange on the top at one end and for the low-pressure steam pipe to be connected to another nozzle at the other end. Any condensation carried over from the high-pressure cylinder and the water that accumulates from condensa-

tion in the receiver itself will collect if in the bottom, so there will be no danger if it should slope toward the end at which the high-pressure exhaust enters, where a large drain pipe should discharge the water into a trap. The receiver should be made of steel plates to conform with the specifications adopted by the American Boiler Manufacturers' Association, and the heads should be dished to a radius equal to the diameter of the shell. One of the heads must be provided with a standard manhole. The nozzles should be of heavy design and riveted to the shell, with calking strips under the flanges. The seam of the shell should be made on the upper half, never at the bottom. The receiver may be supported on concrete piers, but not bolted down, with allowance for expansion and contraction.

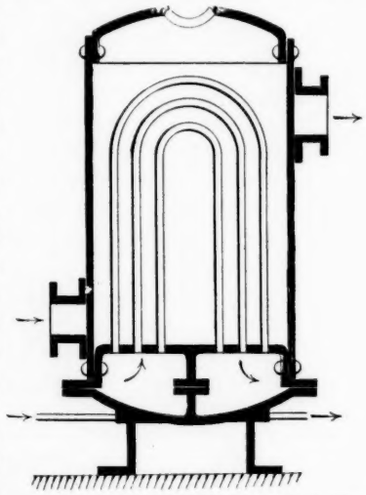


FIG. 36. AIR IS EASILY FORCED OUT OF THE TUBES

Reheating receivers are sometimes called for and installed, but except on pumping engines the reheating part is usually put out of service. If a reheater is desirable, the vertical receiver gives the best results. The reheater should consist of a copper coil, the steam to enter at the top; the lower end connected to a trap. The area of the reheating surface in square feet should be equal to about twice the volume of the low-pressure piston displacement in cubic feet. The exhaust from the high-pressure cylinder should enter at the bottom, the nozzle for connection to the low-pressure cylinder to be near

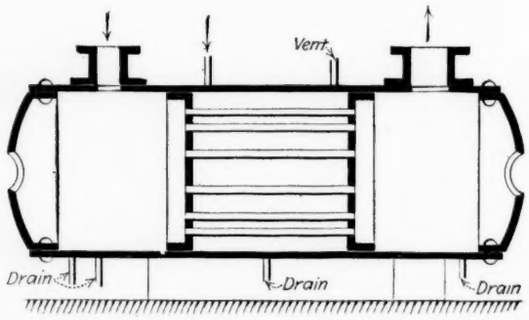


FIG. 37. ANOTHER TYPE OF RECEIVER

the top. Fig. 34 shows a vertical receiver with copper coil, the top consisting of a flange riveted to the shell with a cover bolted on, so that the reheating coil can be inspected and removed if necessary. Both the flange and cover should be of cast steel, thoroughly annealed, of about 60,000-lb. tensile strength. Cast iron must not be used for receiver heads, as it will give trouble. A drain in the bottom will take care of any condensation.

Reheating pipes or coils in receivers act about the same as radiators in rooms; in fact, they *are* radiators and subject to similar conditions. Unless properly vented, air contained in the steam will accumulate in certain places and materially reduce the heating capacity. For this reason the arrangement shown in Fig. 35 should be avoided. The vertical tubes, closed at the top with a cap and screwed into the plate at the bottom, will soon fill with air; in fact, there is no way of exhausting the air from them except by a vacuum pump. Having no vent, their heating effect will be destroyed.

If the tubes are arranged as shown in Fig. 36, the air can be forced out so that they will have the full heating effect, but the trouble with this design is that the tubes are liable to get loose in the plate on account of the constant vibration caused by the inrushing and outrushing steam; if once loose, they will soon begin to leak. There is no saving in steam in a reheater with leaky tubes.

In a horizontal receiver a copper coil seems to be out of place; water will constantly collect in the lower parts and there may be trouble on account of this; the drainage of the coil will be badly impaired. Therefore one of the two designs shown in Figs. 37 and 38 may be adopted.

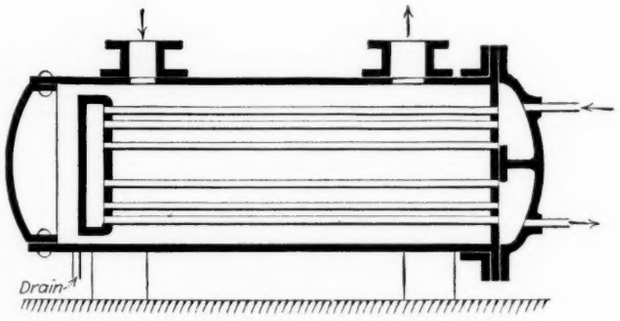


FIG. 38. ANOTHER TYPE OF RECEIVER

Fig. 37 shows two flanged steel heads riveted inside to the shell of the receiver, with steel tubes expanded in place. Brass tubes must not be used, as they will give trouble on account of unequal expansion. Both ends should have a manhole, so that the inside of the receiver and the ends of the tubes can be inspected. Fig. 38 shows another design with horizontal tubes which may freely expand and contract.

[*The next article of the series treats of engine frames.*]

Something About Ejectors

By J. J. B. Trix

The principle underlying the operation of an ejector is to utilize the velocity of steam to impart velocity to water. This idea was first made use of by a German who used it to circulate water in greenhouse radiators. A few years later, a French inventor and experimenter, developed it further and used the steam to force water into the boiler, and the first injector was put on the market.

An ejector is a fitting usually of cast iron or brass, to which are connected the steam supply, suction or water-supply and the discharge or delivery pipes. It contains a steam nor forcer jet and a discharge or delivery tube. These jets are so constructed with internal diameters and tapers as to offer the least resistance to the movement of the steam and water through the ejector and to give maximum efficiency for any specified conditions. They are built in sizes giving varying capacities of from 50 to 15,000 gal. per hr.

During the past ten years it has been a common occurrence to see a description of a home-made ejector in the mechanical papers. This usually consists of a tee with a piece of pipe extending into one end of it. The only possible recommendation a device of this kind can have is its low initial cost. How many times a year it would waste more than the cost of a properly constructed device depends on how much it is used, as it takes a makeshift of this kind only a few hours to consume steam sufficient to equal the cost of an instrument constructed on scientific principles.

Most ejectors are designed to give the best service under average conditions of lift and elevation with steam pressure at 60 to 70 lb. It is possible, however, to build an ejector that will give maximum efficiency under any specified conditions within the range or possibilities of the steam pressure used, temperature of the liquid and the elevation required. The steam pressure must be sufficient to give the elevation desired. It is possible to elevate water at 70 deg. F. 2 ft. for every pound of steam pressure at or above 25 lb. The capacity of an ejector decreases as the suction increases, and it is advisable not to lift over 12 to 15 ft. The temperature of the water or liquid supplied must be low enough to condense all the steam that is necessary to do the work.

Ejectors can be built to operate with air or water under pressure. The water-pressure instrument is fairly efficient, but the efficiency of the air-operated one is very low, and its range is limited. The manufacturer should have detailed information regarding the operating conditions of air- or water-pressure ejectors if they are to give satisfaction. Whenever the elevation necessary is greater than the steam pressure can attain, it is possible to connect ejectors tandem, one elevating the water to the second. This arrangement, however, is not practical with water- or air-operated ejectors.

Condenser Efficiencies

By John D. Morgan

SYNOPSIS—A general discussion of condensers, particularly in connection with capacity and economy calculations. Useful pointers as to care and management for best results are appended.

In speaking of a condenser the first question generally asked is, "What vacuum will it maintain?" and the reply is given as so many inches of mercury. This does not in any way indicate the efficiency of the condenser, but if the question is answered by saying that a certain percentage of vacuum is maintained, then the matter of the efficiency and performance of the condenser is answered. The percentage of vacuum shows the relation between the vacuum corresponding to the temperature of the injection or cooling water and the vacuum maintained by the condenser. Fig. 1 shows the possible vacuum obtained with varying temperatures of inlet cooling water for various percentages of vacuum.

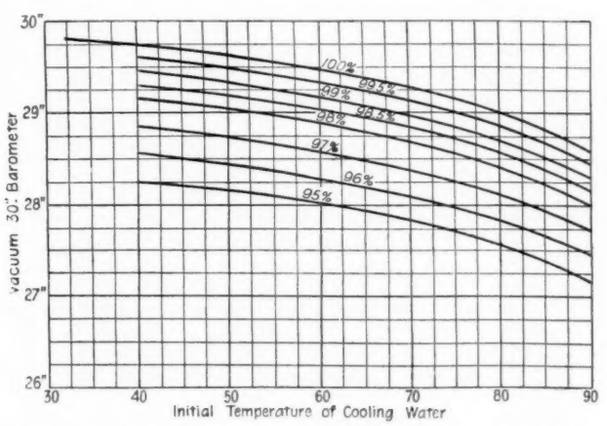


FIG. 1. RELATION OF VACUUM TO CONDENSING WATER TEMPERATURE

It is often necessary to calculate the power to be gained by operating an engine condensing, and it is a very simple calculation by the following formula:

$$Per\ cent.\ of\ increase\ of\ power = \frac{Pr}{P} \times 100$$

$$Horsepower\ gained = \frac{PrAS}{33{,}000}$$

in which

Pr = Reduction of back pressure (pounds per square inch);
A = Area of piston, square feet;
S = Piston speed, feet per minute;
P = Mean effective pressure on piston when running noncondensing.

The next question is, What will be the saving in steam per kilowatt-hour or horsepower-hour? This can be answered only after a test, for the design of the turbine or engine greatly affects the steam consumption.

Fig. 2 shows the variation in the steam consumption of a perfect engine with various terminal pressures.

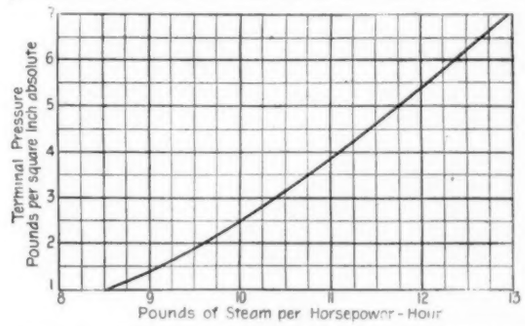


FIG. 2. ECONOMY INFLUENCED BY TERMINAL PRESSURE

Fig. 3 shows the effect of various vacua on a 3,000-kw. turbine designed for 28-in. vacuum as determined by actual test.

The types of condensers most commonly used are ejector, jet, rain type and surface.

The ejector condenser is a very economical unit, and the calculations for the amounts of water needed are similar to those of the jet condenser, which will be discussed later. In the operation of ejector condensers great

care should be exercised to see that the diffusing cone is kept clean; that is, that no foreign matter gets in to break up the circular spray of water. The presence of any foreign matter can be detected by hot spots on the outer cone.

Jet condensers are largely used where an abundance of fresh water is available for boiler-feed water. The

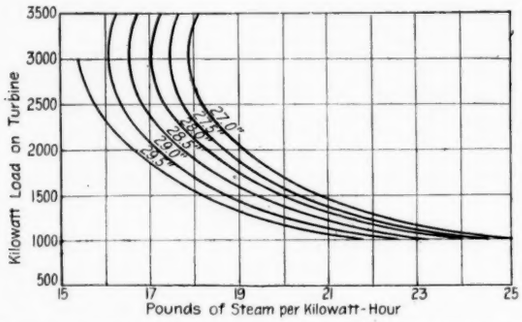


FIG. 3. ACTUAL TEST OF TURBO-GENERATOR SET

cost of jet condensers including pumps is from $1.50 to $3 per kilowatt installed. In many plants where an abundance of exhaust steam is available for feed-water heating, the pumps supplying water to the jet condensers are driven by a motor. The calculation of the amount of water needed to produce a given vacuum with a jet condenser is simple and the formula generally used is

$$W = \frac{H - T_2 + 32}{T_2 - T_1}$$

in which

W = Weight of water to condense one pound of steam to required discharge temperature;
T_2 = Temperature of outlet water;
T_1 = Temperature of injection water;
H = Total heat of steam at condenser pressure above 32 deg.

Fig. 4 shows the vacuum obtainable on a jet condenser with various temperatures of injection water and with various amounts of water.

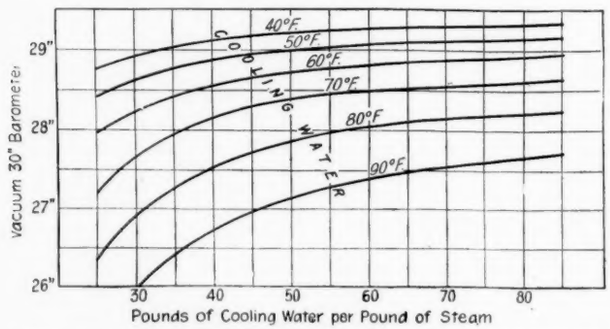


FIG. 4. VACUUM POSSIBLE WITH GIVEN CONDITIONS

The surface condenser has become the principal one because it can be adapted to give practically any vacuum desired. The cost of surface condensers including pumps varies from $3 to $6.50 per kilowatt installed. The power used by the pumps on a surface condenser is between 3½ and 4 per cent. of the power of the main unit at rated load.

The calculations involved in calculating the various factors of surface-condenser operation are a trifle more difficult than with other types and are performed as follows:[1]

$$S = \frac{W(H - T_1 + 32)}{UD}$$

when

S = Cooling surface in square feet;
H = Total heat of exhaust above 32 deg. at condenser pressure;
T_1 = Temperature of condensate;
T_2 = Temperature of inlet water;
T_3 = Temperature of outlet water;
T_4 = Temperature of exhaust steam at condenser pressure;
U = Coefficient of heat transmission (a variable, can be assumed for rough work for plain brass tubes with a water velocity of 25 to 50 ft. per min. as 250);

$$D = T_4 - \frac{T_2 + T_3}{2};$$

W = Weight of condensate, pounds per hour;
X = Pounds of cooling water to condense one pound steam;
G = Gallons of circulating water per minute.

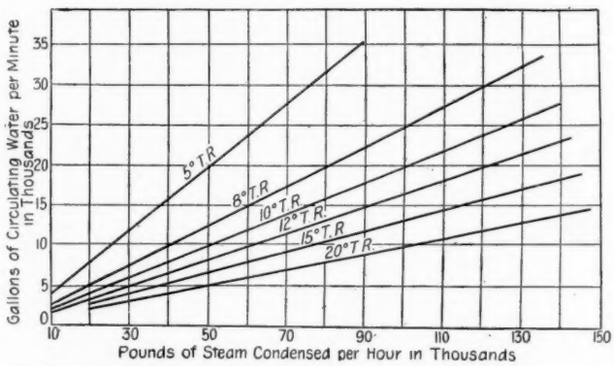


FIG. 5. WATER REQUIRED WITH DIFFERENT TEMPERATURE RISES

In practice the square feet per kilowatt varies between 1 and 2.5.

$$X = \frac{H - T_1 + 32}{T_3 - T_2} \qquad G = \frac{W \times (H - T_1 + 32)}{(T_3 - T_2) \times 500}$$

Fig. 5 shows the gallons of circulating water for steam condensed per hour with varying temperature rises.

If a feed-water heater made of coiled pipe is inserted in the exhaust pipe to the condenser, it will give good results and the heater will also act as a surface condenser and help to maintain a better vacuum. Care should be taken that the steam passage through the heater is sufficient to allow the steam to pass without a drop in vacuum. The tail pipe of a jet condenser should not have offsets, but if it is necessary to have them, they should be made with easy pipe bends—never with pipe fittings. In many plants it is common practice to place the condenser fifty feet or more from the engine and,

[1] "Power" has in the past been inclined to favor the formula $S = \frac{Q}{U} \log_e \frac{ts - te}{ts - t}$ as used by Josse and other European authors. See issue of Feb. 2, 1909, or Kent's Engineers' Pocketbook under "Coefficient of Heat Transference in Condensers." In this formula, S is the cooling surface in square feet; Q the pounds of cooling water per pound of steam condensed; ts the saturation temperature; te the temperature of cooling water at entrance; t the discharge temperature of the water and U the coefficient. Nevertheless a number of authorities use the arithmetical mean.

to economize, to use a small size of exhaust pipe, which results in a vacuum loss of 3 in. to 4 in. between the condenser and engine. This in the long run is poor economy.

To insure efficient operation of surface condensers the following items should be looked after: Circulate as much water as possible through the tubes; keep the tubes clean, both inside and outside; keep moisture out of air removed by the dry-air pump; maintain total absence of air leaks in the condenser and turbine base.

Fig. 6 shows the effect of various amounts of free air per minute admitted to the air pump.

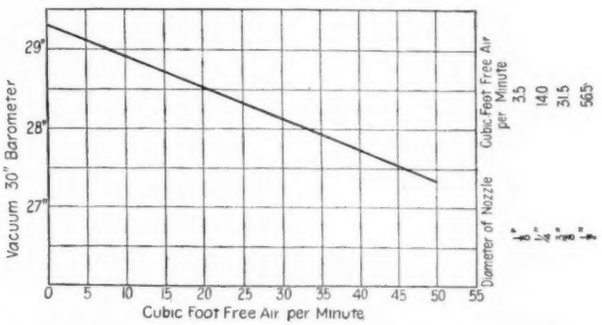
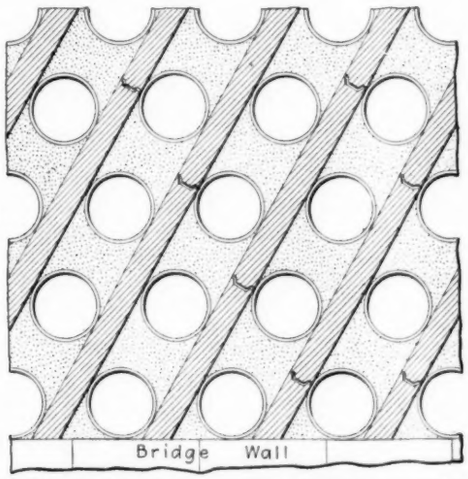


FIG. 6. EFFECT OF AIR LEAKS ON VACUUM

It is often of great value to know the composition of the sediment that collects in the condenser tubes, as it may be an aid to the cleaning of them and will tell whether there is anything in the water that is injurious to the tubes. The following analysis was obtained where salt circulating water was used: Moisture, 8.94 per cent. by weight; loss on ignition, 26.28 per cent.; silica, 18.84 per cent.; alumina, trace; ferric oxide, 44.30 per cent.; zinc oxide, trace; calcium oxide, trace; sulphur trioxide, 1.60 per cent.

Gas-Tight Baffle Walls

Troubles from not keeping vertical baffle walls in water-tube boilers tight have resulted in fuel loss and

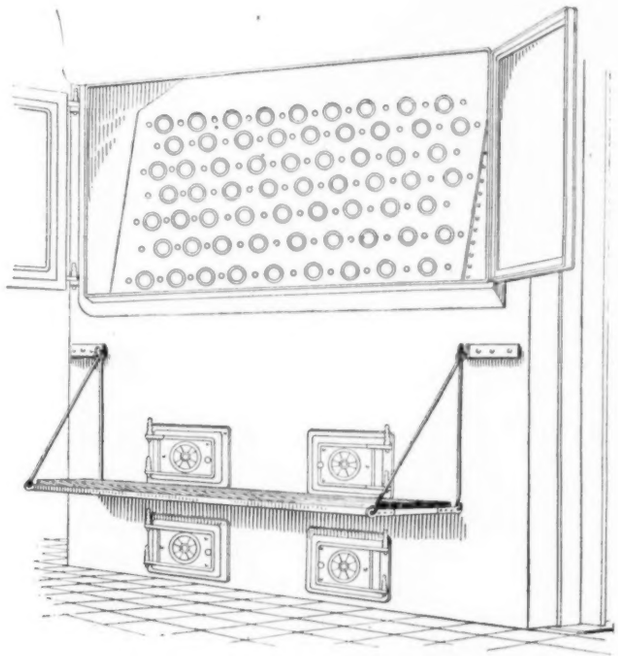


BAFFLE-WALL TILE AND SEMIPLASTIC CEMENT

upkeep expense. Although baffle walls may be tight when a boiler is first put in service, when repairs are required it is practically impossible to get new full-size baffle brick in place. The first place to start economy in making steam is at the boiler, and tight baffle walls will do much to raise the efficiency. To overcome baffle-wall difficulties the B. W. R. Co., 59 Pearl St., New York City, has perfected one that is built of firebrick tile, (see illustration) laid up as inclined shelves on the tubes. The pockets between the tubes are filled with a cement mixture that forms a semiplastic wall that thoroughly ties all together. This construction allows of the removal of tubes without causing the bricks to fall down, and a tight wall can therefore be maintained. The walls are built with or without the iron flame plates, with the tubes in place before the side walls are built, or in old boilers where new baffles are needed. Various sizes of bricks are used to fit the different types of horizontal water-tube boilers.

Portable Boiler-Cleaning Platform

It is common to see a fireman balanced on a box placed in front of a boiler, while washing out and doing other work during the cleaning-out period. The illustration shows a convenient portable platform that can be used with good results and is of such character that anyone can make it. The sketch shows the platform hung in front of a boiler. It consists of a wooden frame on which lengthwise strips are secured. At each corner is a



CLEANING PLATFORM IN POSITION

flat strip of iron, with an eyepiece on one end, and secured in place with small bolts. On the front of the boiler are two flat iron pieces with a hook on the inner end. From these hooks, ⅜-in. rods hang and hook onto the eyepieces of the platform. It requires but a minute to put the platform in place, and it is as easily removed.

Striking Points of the Piston against the cylinder head are not always known. If not, marks should be placed on the guide so that it can be clearly seen at any time that the piston has sufficient clearance at the end of the stroke, which should be kept equal at each end.

A Reliable Grease May Be Made from good cylinder oil and tallow or tallow soap mixed to suit.

Percentage Distribution of Power Costs

SYNOPSIS—Discusses the value of power-plant costs when distributed and expressed on a percentage basis. From the notebook of J. D. Morgan.

In recent years operating engineers have shown a desire to acquaint themselves with all items and things connected with power generation, and this is encouraging. But few have realized the important part cost analyses play in the economic operation of their stations. Nevertheless, such data have a marked influence in that they bring forcibly to the attention the departments that cost the most to run and also the effect of economic operation on the final cost of power.

Primarily, each plant has a fixed minimum production cost; by this I mean that the design of the station fixes the cost of production for certain definite loads. Yet the actual operating cost varies with the efficiency of operation and the station and load factors. So the mere cost figure is of little value as an educational feature, yet the percentage distribution of the cost is of great value. Few engineers can tell what the percentage-cost distribution is, although in the industrial end of almost any manufacturing plant of any size the management can tell just what amounts and what per cent. each department costs to operate.

TABLE 1. PERCENTAGE—COST DISTRIBUTION OF SEVERAL LARGE TURBINE PLANTS

	Plant A	Plant B	Plant C	Plant D	Plant E	Plant F
Boiler room	7.920	8.555	9.109	14.698	4.673	8.976
Turbine room	3.564	3.042	6.275	5.921	2.702	4.737
Electrical	3.366	0.950	1.215	2.172	1.019	2.521
Supervision	4.356	1.331	1.215	4.436	1.085	0.180
Total operating labor	19.208	13.878	17.814	27.226	9.479	16.415
Coal	64.158	63.118	70.648	44.765	77.453	66.214
Water	1.980	6.273	0.202	2.011	0.709	3.463
Lubricants	0.396	0.380	0.405	0.558	0.243	0.734
Miscellaneous material	0.792	0.190	1.215	1.723	1.462	0.997
Miscellaneous charges	0.198	1.521	1.012	.....	.....	.....
Total operating material	67.525	71.483	71.483	49.058	79.867	71.408
Total operation (labor plus material)	86.732	85.361	91.295	76.284	89.346	87.823
Building	0.198	0.577	0.607	0.383	0.664	0.152
Boiler room	2.376	2.281	0.809	1.165	1.107	1.593
Turbine room	0.396	0.571	0.202	0.543	0.111	0.346
Auxiliary apparatus	1.386	0.762	0.405	1.931	0.243	1.510
Electrical	0.594	0.380	.....	0.255	0.089	1.565
Piping	.....	0.380	0.405	1.835	0.310	0.526
Miscellaneous	0.198	0.190	0.202	.....	.....	0.222
Total maintenance labor	5.148	5.134	2.631	6.112	2.525	5.887
Building	0.396	0.380	0.202	0.127	1.373	.....
Boiler room	2.376	6.273	1.417	2.170	3.610	1.053
Turbine room	0.198	0.571	0.202	0.192	.....	0.678
Auxiliary apparatus	0.594	0.762	0.809	2.106	0.399	0.858
Electrical	.....	0.574	0.405	0.144	0.975	3.546
Piping	.....	0.190	0.809	7.804	0.266	0.152
Miscellaneous	0.396	0.190	0.607	.....	0.022	.....
Total maintenance material	3.960	8.938	4.453	12.544	6.644	6.288
Total maintenance (labor plus material)	9.108	14.069	7.085	18.656	9.169	12.190
Total labor (operating plus maintenance)	24.356	19.011	20.445	33.338	12.004	22.302
Total material (operating plus maintenance)	71.485	80.418	77.935	61.602	86.511	77.697
Total labor and material, power station proper	95.841	99.429	98.380	94.940	98.516	100
Other charges to power-station accounts	4.159	0.571	1.620	5.060	1.484	.....
Total, per cent	100	100	100	100	100	100
Net kw.-hr. generated per year	95,403,319	120,349,670	33,246,600	47,875,967	233,015,000	60,691,205
Lb. of coal per kw.hr	2.72	2.81	3.004	3.5171	2.443	3.23
Cost of coal per ton of 2,000 lb., dollars	2.38	2.377	2.32	1.61	2.715	2.959

To illustrate the value of a percentage-cost distribution chart the accompanying tables have been prepared from actual operating records. Table 1 shows the percentage-cost distribution of several large turbine plants.

TABLE 2. PERCENTAGE—COST DISTRIBUTION OF SMALL TURBINE PLANT WITH HAND-FIRED BOILERS

Account Classification	Percentage Cost
Station superintendent	1.98
General supervision	1.07
Station-care labor	1.25
Boiler labor	9.40
Engine labor	4.98
Electric labor	3.12
Fuel for steam	58.40
Lubricants	0.27
Production supplies	0.41
Station expense	5.30
Total operation	86.17
Repairs:	
Building	2.98
Boilers and furnaces	4.65
Boiler apparatus	1.30
Steam accessories	0.58
Turbines	1.58
Mechanical apparatus	1.46
Electric generators	0.83
Accessory electric equipment	0.34
Station tools	0.03
Miscellaneous equipment	0.09
Total maintenance	13.83
Total cost	100
Total current generated	24,874,100
Coal per kw.-hr., lb.	2.656
Cost of coal per 2,240 lb., dollars	3.15
B.t.u. per lb. of coal	14,316
B.t.u. per kw.-hr.	38,023
Net thermal efficiency, per cent	8.98

TABLE 3. COMPARATIVE YEARLY-COST ANALYSIS

	Year A Per Cent.	Year B Per Cent.	Year C Per Cent.
Production salaries	1.23	1.62	1.70
Boiler-room labor		10.35	8.95
Engine-room labor	22.30	6.93	6.88
Dynamo-room labor		2.94	3.16
Station labor		1.00	1.06
Production supplies	5.39	1.74	1.55
Station expense		1.80	1.98
Fuel	58.00	59.2	60.00
Oil and waste	1.93	1.75	1.68
Water for boilers	2.82	2.21	1.97
Water rights	0.06	0.05	.....
Total operation	91.70	85.70	89.00
Repairs:			
Building	0.73	0.90	0.93
Boilers		2.87	3.32
Boiler apparatus		1.17	1.30
Piping	5.75	0.97	1.33
Engines		1.84	1.57
Mechanical apparatus		0.94	0.98
Generators	1.83	0.73	0.75
Electrical apparatus		0.99	0.89
Hydraulic structures	.....	.....	.....
Hydraulic equipment	.....	.....	.....
Total maintenance	8.3	14.3	11.00
Total production costs	100	100	100
Total kw.-hr. generated	244,785,476	244,078,611	259,533,551
Relative cost	100	99.7	90.6

Table 2 shows the percentage-cost distribution of a small turbine plant with hand-fired boilers.

Table 3 shows the value of a percentage-cost distribution sheet for comparing the yearly cost analysis of a plant with other years.

From these tables it will be seen that each plant will have a slightly different percentage-cost distribution, as the design differs in each plant.

The Electrical Study Course—Elements of Magnetism—I

SYNOPSIS—The first lesson was introductory and gave some mechanical analogies of the action of electricity and magnetism. This, the second lesson, discusses natural magnets, permanent magnets, attraction and repulsion between magnet poles, and the earth a magnet.

Before a clear conception can be obtained of electrical machinery, one must first understand the principles of magnetism. Magnets in some form or other enter into all machines for the generation and utilization of electricity. Consequently, at the beginning of this electrical study course it is essential that we direct our attention to this subject.

The discovery of the property of magnets is something that has come down to us from the ancients; the exact dates are not known. Magnets were first found in a natural state; certain iron oxides were discovered in various parts of the world, notably in Magnesia in Asia Minor, that had the property of attracting small pieces of iron. Fig. 2 shows one of these magnets; as will be seen, it looks very much like a piece of broken stone. Fig. 3 is the same magnet after it has been placed in a box of small nails and withdrawn.

The property which the natural magnet possesses of attracting small pieces of iron or steel is called magnetism, and any body possessing this property is called a magnet.

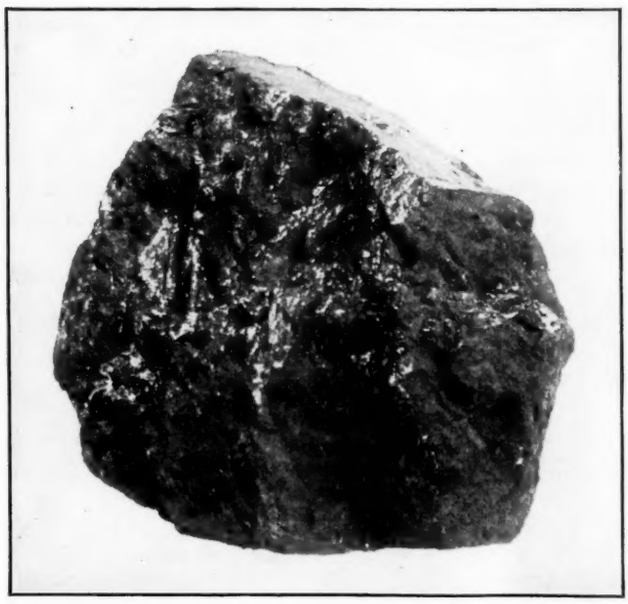


FIG. 2. NATURAL MAGNET OR LODESTONE

Outside of iron and steel there are very few substances that a magnet will attract; nickel and cobalt are the best, but the magnetic properties of these metals are very inferior when compared with those of iron and steel.

When a piece of iron or steel is brought under the influence of a natural magnet, it takes on the same property; that is, it also becomes a magnet and is said to have been magnetized. The greatest effect is obtained by bringing the iron or steel in contact with the magnet. One of the remarkable features of this is that the magnet imparts its property to the piece of iron or steel without any apparent loss of its own. Why this is so will be discussed when we consider the theory of magnetism in the next lesson.

A magnet that is made by bringing a piece of steel or iron under the influence of another magnet is called an artificial magnet. Artificial magnets may be divided into

FIG. 3. NATURAL MAGNET ATTRACTING IRON NAILS

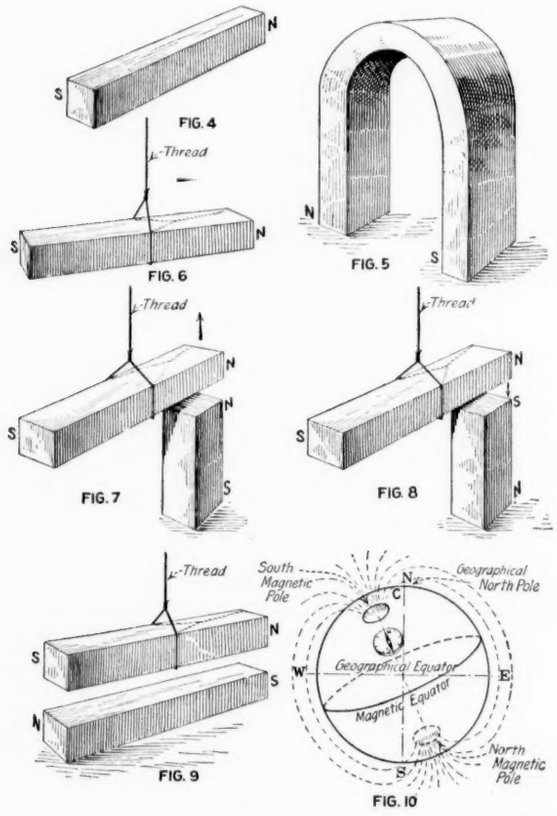
two classes—temporary and permanent magnets. A piece of iron brought under the influence of a magnet becomes magnetized, but when it is removed from this influence, it loses the property of a magnet almost entirely, therefore, is called a temporary magnet. That is, it remains magnetized only as long as it is under the influence of another magnet.

On the other hand, if a piece of hard steel is rubbed on a natural magnet, it will become magnetized, and when removed from this influence, it will retain its magnetic properties. Hence we have a permanent magnet. Permanent magnets are usually made in two forms; namely, bar magnets and horseshoe magnets. When made in straight bars, as in Fig. 4, they are called bar magnets, and when in U-shape, as in Fig. 5, horseshoe magnets.

The natural magnet, when suspended from the end of a thread, possesses the property of pointing north and south the same as the needle of a compass. This discovery was used to advantage by the ancients to direct the course of their ships at sea. Hence the natural magnets got the name lodestone (meaning leading stone).

If a bar magnet is suspended from a string, as in Fig. 6, it will take a position almost directly north and south. The end that points toward the north pole of the earth is called the north or N pole of the magnet. The end pointing to the south pole of the earth is called the south or S pole of the magnet, as indicated in the figure.

If a magnet is suspended as in Fig. 7 and the N pole of a second magnet brought near the N pole of the one that



FIGS. 4 TO 10. ILLUSTRATES SOME OF THE PROPERTIES OF MAGNETS

is suspended, it will be found that they will repel each other; that is, the suspended magnet will move away from the one that is brought near it, as indicated by the arrowhead. On the other hand, if the S pole of the second magnet is brought near the N pole of the suspended magnet, as in Fig. 8, it will be found that they will attract each other and the end of the suspended magnet will be drawn to the one held in the hand. The same effect will also be found at the S pole of the suspended magnet; namely, between like poles there is repulsion, and between unlike poles there is attraction. From this we may write the first law of magnetism, which is: *Like poles repel and unlike poles attract.*

Carrying this one step farther and holding the second magnet under the one that is suspended, a condition will exist as shown in Fig. 9. The suspended magnet will take a position parallel with that of the one held in the hand. Furthermore, it will be found that in this case unlike poles attract, as pointed out in the preceding paragraph.

When the bar magnet was suspended from a string and not influenced by anything else, it pointed approximately north and south, just as it took a position parallel to the second magnet in Fig. 9. Therefore we are in a position to make the deduction that the earth is also a magnet, for it has the same influence upon a magnet as the second magnet had in Fig. 9. This is true. The earth is a magnet, and any effects that may be obtained from a magnet may be obtained from the earth's magnetism.

In Figs. 6 to 9, it was pointed out that unlike poles attract and like poles repel. It was also shown that the end of the magnet that pointed to the north pole of the earth is called the N pole. Consequently, if unlike poles attract, the magnetic pole of the earth must be opposite to that of the magnet; that is, the earth's magnetic pole located near the geographical north pole is a south magnetic pole and that located near the south geographical pole of the earth, a north magnetic pole. The true condition is shown in Fig. 10, which represents the earth and its poles. The position that a compass needle will take is indicated in the figure. It will be seen that the compass does not point due north and south. In order that ships may be steered by a compass, magnetic charts must be used showing the correction that must be made for the declination of the compass needle.

Correct Pressures To Use in Fan Testing

By John L. Alden

The literature of fan testing is incomplete in regard to the measurement and use of the various pressures developed by the fan. It is the purpose of this article to show, not how to measure the pressures, but what pressures to measure.

The mechanical efficiency of a fan or blower is the air horsepower divided by input horsepower. The input to the fan may be measured in any of the standard ways. The output, or air horsepower, of the fan depends on the volume of air handled and the difference in pressure produced by the fan. The volume is usually determined by the use of the pitot tube, anemometer, Thomas meter, orifice or venturi meter. The pressure measurements are usually made by the use of a pitot tube, piezometer ring or static-pressure holes in the circumference of the pipe. All these have been fully covered in textbooks and published articles and will not be discussed here.

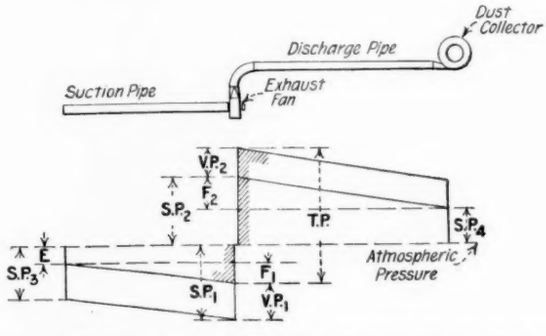


FIG. 1. PRESSURE AT VARIOUS POINTS IN FAN DUCTS

The total pressure existing at any point in a pipe is the algebraic sum of the static and velocity pressures at that point measured directly by the impact or dynamic orifice of the pitot tube. The dynamic pressure in the discharge pipe is always greater than atmospheric pressure and is therefore positive. In this pipe the velocity and static pressures are both positive. In the suction pipe the static pressure is always negative and

greater, numerically, than the positive velocity pressure at the same point. For this reason the suction dynamic pressure is always less than atmospheric pressure and hence negative. The total pressure difference produced by the fan is the algebraic difference between the dynamic pressures as measured on the two sides of the fan as shown in the diagram, Fig. 1, where

$T.P.$ = Total pressure developed by fan;
$S.P._1$ = Static pressure at fan inlet—negative;
$S.P._2$ = Static pressure at fan outlet—positive;
$S.P._3$ = Static pressure at end of suction pipe—negative;
$S.P._4$ = Static pressure at entrance to collector—positive;
$V.P._1$ = Velocity pressure at fan inlet—positive;
$V.P._2$ = Velocity pressure at fan outlet—positive;
$F._1$ = Friction loss, suction pipe—negative static pressure;
$F._2$ = Friction loss, discharge pipe—positive static pressure;
$E.$ = Entry loss, suction-pipe inlet—negative static pressure.

This represents an exhaust fan drawing air through a suction pipe and discharging it into some sort of dust collector or receiver, through a discharge pipe of different diameter from the suction pipe. The discharge pressures are represented graphically as falling above the atmospheric line and the suction pressures below. The only pressures essential to the computation of the air horsepower of the fan are the two static and two velocity pressures measured at the fan. For a proper understanding of the composition of these pressures, the diagram has been extended to show the conditions at the ends of the suction and discharge pipes. The static vacuum at the mouth of the suction pipe consists of that part which produces the inlet velocity and that necessary to overcome the entry loss due to the contraction of the liquid vein. The difference in static pressures at the two ends of the pipe is used up in overcoming friction and eddy losses. The static pressure in the discharge pipe is that required to overcome friction and the resistance imposed by the dust collector.

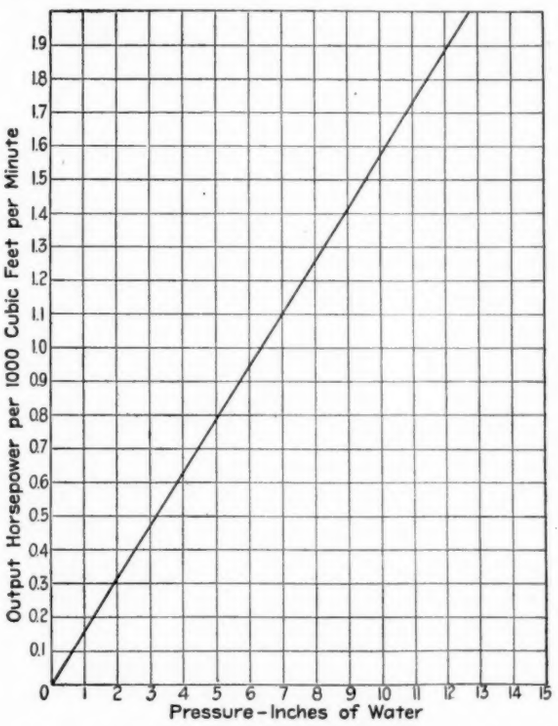


FIG. 2. HORSEPOWER REQUIRED FOR VARIOUS PRESSURES

A number of published accounts of fan tests give erroneous results and conclusions because the calculations are based on the wrong pressures. It is customary with many engineers to base their figures on the sum of the two static pressures and the discharge velocity pressure. As one velocity pressure has already been included in the static suction, it is plain that this method gives the fan credit for creating more pressure than it actually does. It is too high by the amount of the suction-velocity pressure, and consequently gives too high an efficiency. This method is correct only when the inlet velocity is zero, which never occurs when the fan is delivering air.

When the inlet and discharge pipes have different areas, the numerical sum of the two dynamic pressures must be used as the true total pressure produced by the fan. If the two pipes are the same size, the sum of the static pressures is identical with the sum of the dynamic pressures. If a correct test of an open-inlet blower is desired, it will be necessary to attach sufficient suction piping to enable the static suction to be measured. If accuracy is not essential, it will be necessary to figure the inlet velocity from the discharge velocity by using the ratio of the discharge area to the net inlet area. In addition, the loss at entry into the fan inlet must be estimated and considered as part of the static suction pressure. To do this it will be necessary to assume a coefficient of influx corresponding to the general shape of the inlet.

When the proper pressures and the volume of air have been determined, the air horsepower of the fan may be quickly found from the curve, Fig. 2, based on a 30-in. barometer and 50 deg. F.

Designing a Flywheel

By G. P. Pearce

"You look worried, Bill," said William Steelworth, as he stepped into the engine room.

"Well, I am kind of up against it," said Bill. "You see, it is this way: The boss wants me to figure out a flywheel for him, to go on that machine he is experimenting with, and I don't know just how to set about it."

"There is nothing very complicated about flywheels if you only get the right point of view; how much work does this machine have to do?"

"The boss says the machine takes 15 horsepower while squeezing, which lasts six seconds."

"Well, that is pretty definite information, Bill, but didn't he tell you how much time was lost between squeezes in charging up and getting ready?"

"Yes, he did mention that it took from 18 to 20 seconds getting the next charge in place. That was all the information he gave me, and I'll be ding busted if I know just what to do next."

"How fast does the pulley shaft run?"

"Oh, that makes 900 r.p.m. I had to find a pulley for it when the experiments were being made."

"How much speed can you lose during the squeezing operation; that is, how much will it be possible to let the machine slow down? Because, as you know, it is

necessary to slow a flywheel down in order to get any power out of it; or rather, the taking of power from the flywheel reduces its speed."

"Mr. Steelworth, I don't know, but I'll run over to the office right away and find out," and Bill Holmes hurried out.

While he was gone, William Steelworth took a piece of paper and made the following notes: Power to be delivered, 15 hp.; time power is needed, 6 sec.; time for flywheel to pick up speed, 18 sec.; maximum speed of flywheel, 900 r.p.m. Soon Bill returned with the information that the machine could slow down 25 per cent.

"Let us sit down here and figure this thing out, now that we have the necessary data," said Mr. Steelworth. "In the first place, let us see how large in diameter the flywheel can be. Now, the maximum safe speed for cast-iron flywheels with rims in one piece has been found by experience to be 150 ft. per sec. on the face, and so the maximum diameter can be obtained thus: 900 r.p.m. = 15 rev. per sec.; 150 divided by 15 = 10 ft. circumference = 3.18 ft. diameter. Let us say 38 in. diameter is the largest cast-iron flywheel it will be safe to use at a speed of 900 r.p.m. The next question is if a flywheel of this diameter can be used on the machine."

"That is too big," said Bill. "It would get in the way of the hopper, for I measured it up the other day and found that 34 in. is the largest that can be used."

"Well, we will decide on a 34-in. diameter wheel then, so that's settled. Now, let us see how much energy we have to store in it. What source of power are you going to use to drive this machine?"

"An electric motor, and I am to order it as quickly as possible so it will be here on time, but I don't know just what size to order."

"How much power does it take to run the machine empty?" asked Mr. Steelworth.

"It turns quite easily; two horsepower should be ample."

"Well, here is the way we want the power: There will be 2 hp. needed for 18 sec. and then 15 hp. for 6 sec., which completes the cycle. Now 2 hp. for 18 sec. is 33,000 × 2 × 18/60 = 19,800 ft.-lb. And 15 hp. for 6 sec. is 15 × 33,000 × 6/60 = 49,500 ft.-lb., which is 19,800 + 49,500 = 69,300 ft.-lb. in 24 sec. This would be an average horsepower of 69,300 × 60/24 = 173,000 ft.-lb. per minute, or 173,000 divided by 33,000 = 5.25 hp., which is the average horsepower needed right along. The nearest commercial motor to this size is 7½ hp., and so that is the one we will decide upon."

"What speed motor shall we get?" asked Bill.

"Well, the higher the speed the cheaper the motor provided it does not mean extra countershafts, belts and pulleys, in order to reduce speed again. In this case, however, the machine is a high-speed one and so we can easily take the 1,800-r.p.m. motor and use only a single 2 to 1 reduction. The next thing to decide is how much we can safely load up the motor for a few seconds, and this can be taken at 150 per cent. overload for these conditions; and notice that at 150 per cent. overload the speed will drop to 85 per cent. full-load speed; that is, 1,800 × 0.85 = 1,530 r.p.m. This will give the flywheel an opportunity to slow down from 900 to 900 × 0.85 = 765 r.p.m. and thus enable it to deliver power to the machine."

"This is certainly quite clear so far," said Bill.

"We have now enough data to start figuring out the flywheel," said Mr. Steelworth. "First let us see what the motor will do during the operation of the machine when it is needing the 15 hp. During these six seconds the motor will deliver 7½ to 7½ × 1.5 = 11.25 hp., or an average horsepower of (7½ plus 11.25) divided by 2 = 9.375, say 9 hp. This leaves the flywheel to supply 15 less 9, or 6, hp. for 6 sec. while dropping from 900 to 765 r.p.m. Expressed in foot-pounds this is 6 × 33,000 × 6/60 = 19,800 ft.-lb. So we want a flywheel that will have, say, 20,000 ft.-lb. more energy at 900 r.p.m. than it has at 765. A simple way to tackle this is to assume a flywheel 1 in. thick and see what it will do; then the actual face of the flywheel can be obtained. Suppose we have a flywheel 34 in. diameter 1-in. face and 4 in. deep rim, which is an area of ($34^2 \times 0.7854$) — ($26^2 \times 0.7854$) = 910 — 530 = 380 sq.in., or for 1 in. thick equals 380 cu.in. This will weigh 380 × 0.26 = 99 lb. Now there is just one radius at which, if this weight were all concentrated, the result would be exactly the same as far as energy stored is concerned, and this is called the radius of gyration; for a cylinder it is

$$\sqrt{\frac{R^2 + r^2}{2}}$$

where R is the outer and r the inner radius of rim. For the flywheel we have in mind this will be

$$\sqrt{\frac{17^2 + 13^2}{2}} = \sqrt{\frac{289 + 169}{2}} = \sqrt{\frac{458}{2}} = 15.15 \text{ in.}$$

The circumference at this radius is 7.95 ft., and the velocity of this is 7.95 ft. × 15 = 119.2 ft. per sec. We have therefore a weight of 88 lb. moving at 119.2 ft. per sec., and the total stored energy is easily found from the formula for kinetic energy:

$$\text{Energy} = \frac{Wv^2}{2g}$$

where W = weight in pounds, v = velocity in feet per second and g = gravity. Applying this we have

$\text{Energy} = (99 \times 119.2^2) \div (2 \times 32.16) = 1{,}410{,}000 \div 64.32 = 21{,}900$ ft.-lb.

which is the total energy contained in the wheel. Going over these figures a second time, only using 12.75 revolutions per second for the revolutions gives a contained energy of 15,800 ft.-lb. Subtracting this from the first gives 6,100 ft.-lb. available due to reduction in speed for each inch of face. The total energy wanted is 20,000 ft.-lb., so the face of the wheel will be 20,000 ÷ 6,100 = 3¼ in. Your required flywheel is 34 in. outside diameter, 26 in. inside diameter and 3¼ in. thick, 6 oval arms, and so your terrible problem is a simple one after all, isn't it? As a safety precaution, however, it may be best for you to order a wheel made of cast steel instead of cast iron, for that speed and service."

Bill agreed that it wasn't difficult when all the points were made as clear as Mr. Steelworth had made them.

"You didn't have the right point of view to begin with, that's all," said Mr. Steelworth, as he said good-bye.

Tests Are Best Conducted on the individual bearing on which the oil is required; no two conditions are exactly alike. In practice the lubricant to select is that which is the best for the average of a given class of bearings operating under nearly the same conditions, to minimize the grades or kinds to be kept in stock.

Editorials

The Water-Power Situation

There is in the United States a large amount of undeveloped water power going to waste. In the meantime men are working nights to dig out of the bowels of the earth the limited supply of coal stored there, and other men are industriously burning it to develop the power that might be gathered as well from the falling water.

Why are these water powers not developed?

Because it takes money to develop them, and the men with the money will not put it into developing water powers, because the people want to retain the control of such natural resources, so that they will not be held up for power in the future, as they are for coal today, owing to the control of the supply and distribution by the purveyors.

The continued non-use of these water powers means a sustained drain upon the national resources—a needless use of a limited supply of fuel at a time when the social organization is becoming more and more dependent upon it.

If the water powers are to be developed, the Government must develop them itself or allow private enterprise to do so upon terms that will induce the venture.

What terms does the capitalist want? Will he interest himself and his money upon any condition short of a virtual surrender by the people of all their rights and interests?

Nobody wants the capitalist to lose money. Nobody expects him to risk his money in a venture that does not offer such evidence of stability and promise of profit as to commend it to the prudent investor. But he hesitates to tie up capital in the development of water power and its attendant distribution, for fear that the Government will take it away from him just as soon as it begins to be profitable.

Would he develop a power if the Government would give him the privilege to do so, upon the condition that the power should be sold at a price which would pay a fair profit and interest upon the capital actually invested, and that the privilege should not be revoked without providing that the capitalist should have received back, in the course of the transaction, in addition to a fair profit, every cent of capital involved, with a generous interest on it for the time during which it had been locked up? He should also be relieved, at their cost to him plus interest and profit upon their cost, of collateral investments, such as distributing systems, etc.

If the capitalist would be willing to undertake the development of these water powers upon these terms, there ought to be no difficulty in giving him the opportunity. There ought to be no charge for the privilege, for such charge would be simply passed on to the consumer. The capitalist ought not to shy at the possibility of the property being taken over by the Government at any time, if he is assured that the taking over means simply the return to him of his investment with generous interest for its use. And there would be little likelihood of the revocation of the privilege so long as the capitalist or his organization furnished satisfactory service at cost plus a fair profit.

Unless those who are seeking to acquire the water powers of the country are willing to undertake their development on these terms, they ought to cease their accusations that the Government will neither allow them to develop the water powers nor develop them itself.

And unless somebody comes forward and wants to develop them upon some such terms pretty soon, there is no better activity for the people, no better use for their common means, than the development by themselves of their own natural resources for their own use and benefit.

Overfusing Electric Circuits

Of all the abuses in the electrical industry, none is more flagrant than that found in the use of fuses for circuit protection. In most cases, when the circuits and equipment are installed they are properly fused, and must be so to get the sanction of the fire underwriters or local inspection board. It is regrettable that many times the proper protection ends here, because, owing to misapplication of the motor or controller or improper adjustment of the machinery that the motor is driving, the fuses are blown. Then, instead of the defect being remedied at the source of trouble, the size of the fuses is increased. Overfusing is serious enough when it is done with standard inclosed fuses and is a practice that is to be discouraged. But when it is done by bridging the fuse cartridge with a piece of fuse wire many times the capacity of the circuit, or with copper wire, which is not uncommonly used for this purpose, a menace to life and property is created that is hard to overestimate. One of the inexcusable features in this practice is that it is often perpetrated by those who are in a position to know the seriousness of such abuses.

A circuit heavily overfused is just as much of a menace to a community as a boiler with its safety valve tied down. True, the former cannot cause a serious explosion, but it is a serious fire hazard. Probably if it were possible to get reliable data on the matter, we would find that overfusing of electric circuits causes a greater loss of property than steam-boiler explosions. One of the great difficulties in setting forth the seriousness of this whole proposition is the lack of evidence, whereas in the boiler explosion the result is the evidence and there is nothing else that could produce the effect. In a fire caused from overfusing, the evidence in most cases is burned up, and those who may be in a position to know the true cause are willing to admit most anything but defective electric work.

Almost every experienced electrical man can recall cases where electric elevators have been left overnight with the brake set, but owing to overfusing and the controller switch failing to open, the machine completely roasted out and no one was any the wiser until the next

morning. The only reason that they were then, was due to the fact that the elevator equipment was located in a fireproof room instead of a tinder box as many are. In the latter case the evidence would have been burned up with very small chances of the true cause of the fire being discovered. Many pump and compressor motors have been roasted out from overfusing without anyone knowing anything about it until it was discovered that the source of supply that these devices were supposed to maintain had failed.

Those who opposed the movement promulgated for cheaper electric-wiring methods probably acted more wisely than they knew, because until something has been done, either by the enactment and enforcement of laws or otherwise, against such practices as overfusing, there seems to be but one safe course and that is to make the installation as near fireproof as possible. An educational campaign carried on by the insurance and central-station companies against this practice should be productive of good results, and closer attention paid to this abuse by the local inspectors should tend to prevent overfusing. The latter is fraught with its difficulties, however, for many an innocent looking thirty-ampere cartridge fuse has been bored out and refilled with sixty- or seventy-five-ampere fuse wire.

James Watt's Anniversary

Progress is the fabric spun on the loom of collective human effort.

Just as men are but the composite of all those who have gone before plus the usual meager originality of soul, of mind and skill they manifest, so, too, are nearly all noteworthy human achievements the composite of previous discoveries. If Franklin had not flown his kite, if Faraday and others had not persistently toiled in research until the shadows of dawn vied with those produced by the laboratory candle, Marconi's wireless would not today bring succor to the shipwrecked from out the thin air. If early investigators had not caught a glimpse of reality through the haze of speculation, Archimedes could not have boasted of lifting the earth with a lever, or Pasteur would not have found the key to communicable diseases.

James Watt, inventor of the steam engine, was born one hundred and eighty-one years ago this month. The tremendous forces of fire and water and vacuum, harnessed, pulled the heavy load of industry, and the burdened workers relaxed their muscles and smiled in gratitude. With the engine's aid the productiveness of human toil increases beyond the voluptuous dreams of the ancient irrigators of the Nile Valley. Kings pay homage to the inventor, and literature wipes from his hands the musty smell of mortality.

It is fitting that they should. But Watt was the chosen. The world had borne him on to the pinnacle of success, and having arrived there, he knew enough to get off and apply what had been given him.

If the Marquis of Worcester and Solomon De Caus had not experimented, if Galileo had not suspected the existence of atmospheric pressure, if Savery, Papin and Newcomen had not built serviceable engines, James Watt, the instrument maker of Glasgow, would not have achieved success. But he brought together the forces, he had the vision to see their unification embodied in a machine to free human muscle from the yoke. He made it. It ran.

It Pays To Specialize

During an analysis of salary problems recently conducted in a public-utility hearing, the point was brought out that the assistant superintendent of construction received a yearly salary slightly exceeding that of his immediate superior. As explained by the manager of the company, the assistant happens to be a specialist, while the department head is an executive, whose duty is mainly to supervise in a broad way the construction tasks. "I would not hesitate," declared the manager, "to pay a subordinate more than his superior in any instance where I felt that his services were worth it."

Hats off to a management that has the courage and good sense to pay a man solely with respect to its opinion of his worth; one that can see his value in relation to his particular technical duties without suffering financial astigmatism just because this engineer happens to report to an executive of more general duties. Who was it that said: "If a man can do any one thing better than anyone else, the world will wear a beaten path to his door no matter how deep in the woods that door may be located"?

In the September fifth issue, *Power* commented upon the statements of Percy G. Donald, a large British buyer, in the London *Ironmonger* in favor of American-made pipe and the superior condition in which it arrived on the job in Egypt, where he supervised the installation. This statement is given greater significance by the recent arrival in this country of a commission appointed by the Argentine government to supervise the manufacture of 65,000 tons of cast-iron pipe for one of their government's departments. This contract was awarded to an American company after competing with several British concerns which have been awarded a number of contracts for similar materials. The disappointment of the British interests is expressed in "The Review of the River Plate," published in Buenos Aires. They feel that some high motive must have actuated the Argentine government in awarding this contract to an American concern at a somewhat higher price than that of the British competitors. This high motive seems to be expressed in Mr. Donald's statement, and the transaction manifests that it is not necessary for the American manufacturer to meet the low prices of his European competitor if he can demonstrate the superiority of American-made materials.

According to the fifth annual report of the Chief Inspector of Locomotive Boilers for the Interstate Commerce Commission, just issued for the fiscal year ending June thirtieth last, there were forty-one boiler explosions of locomotives employed in interstate commerce, killing twenty persons and seriously injuring sixty-four. It is notable that in no case was the shell of the boiler ruptured. Twenty-three appear to have been attributable to failure of the crown-sheet, where no contributory causes were found, and sixteen were due to failure of the crown-sheet because of low water. Two were firebox explosions, one traceable to defective stay-bolts and the other to foaming. Considering the large number of locomotives engaged in interstate commerce and the hard service to which they are necessarily subjected, the number of explosions does not seem great and speaks well for the rigid inspection to which they are subjected.

Correspondence

No Water in the Boiler

A four-story building is heated by two water-tube heating boilers. They were recently in charge of the janitor, who evidently was not "at home" as a fireman. Observing two gages of water in the glass, he proceeded to build a fire, but the steam gage did not move. At length he opened the fire-door and saw that the tubes were red-hot for there was no water in the boiler.

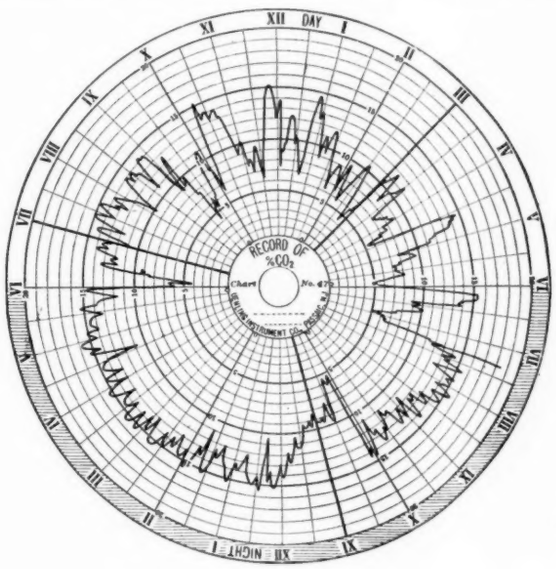
The tee at the bottom of the water-column pipe had become plugged up with scale and dirt and enough water had remained above when the boiler was emptied to half fill the glass. Had he opened the try-cocks before starting the fire, as he should have done, he would have seen by the nonreturn of the water that the boiler was empty.

The boiler is ruined, as all the tubes are badly burned; the brick setting is cracked open on the side in a dozen places. The loss will amount to $500 at least.

Newark, N. J. W. T. Osborn.

Of What Use Is CO_2 Apparatus?

I have seen several articles on the use of the CO_2 apparatus lately and the questions asked: Of what use is it? What will it do in a small plant especially? The CO_2 machine alone will not do a thing for anyone, and it is not worth the room it takes up in any plant if not



SAMPLE CHART RECORD OF CO_2

carefully studied, and followed by the continual application of its indications in stoking. This can be done to the benefit not alone of the owner, but of the men who do the work by lessening their labor.

The sample chart, which is no exception, shows what can be done. The good average CO_2 shows that the fire was receiving attention when needed. A better steam line can be made with good CO_2 for when we have good CO_2 we have steam, and this being the case, there certainly must be a saving in fuel. Besides, there is an influence on the men that leads to more careful stoking, teaches them to look for the small things and to correct them—not alone at the fires, but about the plant in general. To get good CO_2 means that the fires must be given closer attention—not some of the time but all the time—or the chart will tell the story. Stoking at the present time, when fuel is so expensive, is a matter of a great deal of importance, and the man who can and will work with the machine is not simply a coal heaver, a thing of the past. It is amusing to see how some of the smart ones get left, making probably 6 or 8 per cent. CO_2. Those who cannot be taught are the ones that are not wanted at any price, as they will waste their wages in fuel and not know it. Asa P. Hyde.

Binghamton, N. Y.

Unusual Condenser Experience

In 1912 a turbine-driven jet condenser was connected under a 750-kw. turbine. The 12-in. suction, 175 ft. long, 16 ft. lift, was made of bell-and-spigot pipe. In starting up, the condenser vacuum was secured by means of a steam siphon. Soon after completion it was noticed that the vacuum did not hold up properly. The pump was speeded up, giving temporary relief, but the condition grew worse, and greater speed was resorted to, until the normal 2,200 r.p.m. became 2,800.

Several changes were made; the bell-and-spigot line was replaced with a flanged line of the same size, a twin strainer installed, etc., but still the vacuum was not satisfactory. When the condenser was blanked off, 29 in. vacuum could be obtained. The exhaust line from the power turbine was then fitted with a fair quality of rubber insertion packing, with the good results for about a month when the vacuum again began to drop for no apparent reason, as it seemed hardly possible that there could be air leakage again.

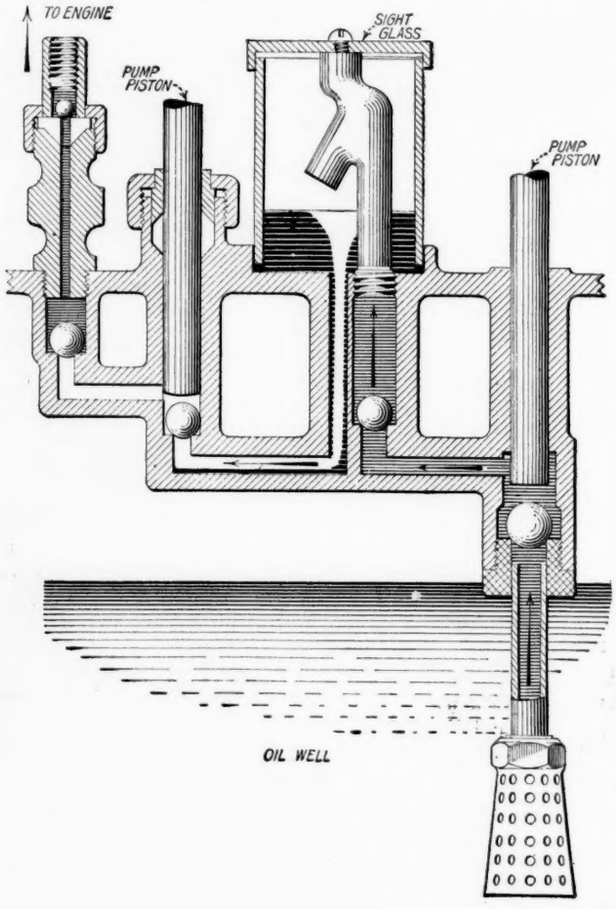
One conclusion was that the condenser was too small and that its engine was not powerful enough. To locate the trouble, however, was the only answer. Air leakage seemed apparent, but no candle test would prove it. Plenty of asphaltum paint was used on joints under vacuum with no good results, but it seemed plausible that the steam-line gaskets under vacuum might be imperfect. The bolts were all taken up—here lay the cue. Could the bolts have a turn or more taken up with a two-year old gasket still doing its work properly? It seemed hardly reasonable. Soft superheat gaskets of asbestos and rubber were made ready, and the night and day shifts were put to work taking the 30-in. line down. At the top of the condenser the gasket was merely vulcanized, but as the power turbine was approached conditions grew worse, until at the turbine nothing but powder remained of what was once a rubber insertion packing. The infil-

tration of air under vacuum can be imagined, and it is apparent that no candle flame could detect so widely distributed a leak. The new gaskets were put into place and the turbine run noncondensing for a day, then the flange bolts were taken up again to insure tightness. At last there was an end to the trouble; 28 and sometimes 28½ in. vacuum was obtained with 60-deg. water.

Little Falls, N. Y. R. A. PACKARD.

Why Lubricator Pump Will Not Feed*

In regard to Mr. Ralston's lubricator trouble as described in the issue of June 27, page 922, and discussed in several later issues, the cold oil is so viscid that under the low head it will not flow into the suction pipe of the



SHOWING VORTEX IN OIL BODY IN LUBRICATION PUMP

force pump fast enough to prevent cavitation, or the forming of an opening which allows air to get into that chamber. For instance, the drain pipe of a washbowl sucks the water out of the bowl faster than the low head will allow it to run in and fill the place of that which runs out, in that way making the well-known vortex. This thick oil under the low head is unable to flow in fast enough to fill the space voided by the plunger, with a similar result and the taking in of air.

We suggest the following remedy: That the lubricator be placed on the cylinder or steam chest of the engine, for when so placed the temperature of the oil remains practically constant. Another method is to have a heating coil put in the inside of the lubricator reservoir or underneath it. Otherwise the oil temperature changes and the ball valves in the pump cannot seat quickly.

When the oil becomes thick and the ball has a tendency to float, part of the oil is forced back into the reservoir before the valve closes. The same problem is encountered where any heavy liquids have to be pumped.

Detroit, Mich. MANUFACTURER.

*See page 174, Aug. 1, 1916.

Brass-Polishing Liquid

There have been several formulas given for brass polish, but I think the following one will do the work quicker than any previously given.

For one gallon of polish take three quarts of hot water and stir in one-half pound of oxalic-acid crystals until dissolved, then add one teaspoonful of baking powder, one tablespoonful of table salt, stir in one pound of XX American tripoli and add one quart of cold water, making a gallon in all.

Dampen a piece of waste with the polish and rub it over the brass and polish with dry waste.

Blacklick, Ohio. L. A. COLE.

"Hunting" Caused by a Shaving

A 50-kw. generator direct-connected to an engine turning 360 r.p.m. was used on Sundays when the load was light. Going on watch one Sunday, I noticed a very slight fluctuation in the voltage, so decided to put in another engine and investigate.

The governor was of the inertia type, and my first move was to examine the main pin. Upon removing the grease cup I found a shaving of wood in its base crosswise of the hole and large enough to plug it. This had prevented the pin from being lubricated, and the extra friction was enough to cause a slight "hunting." One cannot be too careful in watching for foreign matter in lubricants. GEORGE B. LONGSTREET.

Tufts College, Mass.

Oil-Burning Boiler Furnace

In the issue of Sept. 26, page 464, a home-made oil burner and a furnace for burning oil were shown and described, and in the issue of Dec. 5 Mr. Long states that he is of the opinion that it is an infringement on a patented burner and gives a cut of the original Matteson non-clogable oil burner. As patentee of the Matteson burner I beg to state that Mr. Camp's burner is not an infringement, but like Mr. Long, I would be interested in knowing what the evaporation per pound of oil is, also what percentage of steam is used to atomize the oil and how long the shell of the boiler over the fire will last before it is bagged.

Mr. Long goes further and states that the burner that he shows (the Matteson burner) was discarded some years ago as lacking in the principles of a good oil burner; namely, assurance of atomization. If Mr. Long came to "this neck of the woods," he would find that the burner is far from being discarded, but is and has been in service, giving excellent satisfaction, for the last seven years.

In the issue of Sept. 19 Mr. Long has an illustration of a burner designed by himself, and I am of the opinion that it is nearer an infringement than the one described Sept. 26, previously referred to.

If Mr. Long thinks that the Matteson burner is a back number, I would be glad to put it up with the Long or any other burner for a general test as to percentage of steam used for atomization, evaporation, range of fire and length of time that each burner will run without cleaning. V. MATTESON.

Seattle, Wash.

Educational Visits to Plants

Recognizing the elements needed in the education of the stationary engineer, Local No. 16, N. A. S. E., of Scranton, Penn., has, under the leadership of Charles J. Mason, added plant visitations to its lecture and study program. The photograph shows the association "in action" on one of these occasions, when indicator and planimeter practice was the feature. The visit to the plant is arranged for in detail. First, the assistance and coöperation of the plant manager or superintendent and the chief engineer are secured, and the engine and other apparatus are thoroughly prepared for instruction purposes, so as to economize time. The session at a power plant from 8 to 10:30 p.m. is attended by members and many invited friends. A trained man in charge of the exercises explains the apparatus and instruments to the different groups, and all are given the same opportunity to take part. The association owns an indicator and has a planimeter available. Each visitor takes one or more cards, if he chooses, and makes the horsepower calculations. Groups discuss the methods, errors, defects in valve setting, the possible improvements, etc. Many, especially among the beginners, have never actually used

PRACTICE IN THE USE OF THE INDICATOR AND PLANIMETER

an indicator or a planimeter. Dexterity and a full knowledge of their "fine points" come only from practice. The method of attaching the indicator is quickly learned, and the measurement of an area to get the m.e.p. can be made with confidence after very little instruction where the actual work is done.

That the visits are attractive is proved by the large attendance even in stormy weather and the interest taken in the work. The attitude of those about the indicator and the planimeter table, as shown, is but a slight expression of the actual interest. The data gathered and the experiences from a plant visitation are used to good advantage in blackboard work at subsequent meetings, for practical everyday work is coupled with the theoretical.

The plant shown is the large, well lighted and ventilated engine room of the Scranton Textile Co., and the engine is an Allis-Chalmers noncondensing 22x48 in. operating at 80 r.p.m.

Any committee should exercise great care in selecting the plants for its educational work, for while all the plants available may be good, many of them may not be suitable for instruction purposes, and the meeting together of a large assembly of men requires considerable open-floor area. Then, while the visits are made to plants of several types, it is preferable to begin the indicator program with a slow- or medium-speed engine, as this type is somewhat easier to manipulate for instruction purposes, especially by beginners. The program for visitations will include engine, boiler and pump tests, flue-gas analysis, inspection of gas and oil engines, refrigeration plants, long-distance steam transmission, mills, elevator plants, steam-heating plants and the like. Not only are the technical, mechanical and routine features taken up and discussed, but the business features of plant engineering, as far as these concern the operating engineer, are studied. Practical application is made to as great an extent as possible. F. W. BRADY.

Scranton, Penn.

An Expensive Laxity

Anyone who has had to burn bituminous screenings realizes that the size and the percentage of different sizes affect the furnace operation and economy, and while one combination of sizes gives better results than another, no two deliveries are the same. After the firemen become familiar with one lot and the most economical manner in which to burn it, another combination of sizes is received. There is a loss of efficiency in the furnace, heat loss due to absorbed moisture in the smaller aggregate and a loss of the fine particles through the grate. The amount of moisture absorbed by coal depends very largely upon the size of the pieces. The smaller the lumps the greater the absorption, hence coal dust causes more loss in heating value through moisture than screenings of the nominal size. Conditions as regards uniformity of size have been getting worse for a long time, only about 50 per cent. being of the size designated, the remainder ranging from the nominal down to dust. The reason for this is not far to seek, and it is a sacrifice of quality to quantity.

Much is said about the advantage of purchasing coal on specifications that stipulate the heating value, the maximum moisture, ash, sulphur, etc., per pound of coal. It would seem to the advantage of the consumer to include a clause that screenings should contain definite percentages of certain sizes. For example, 1½-in. screen-

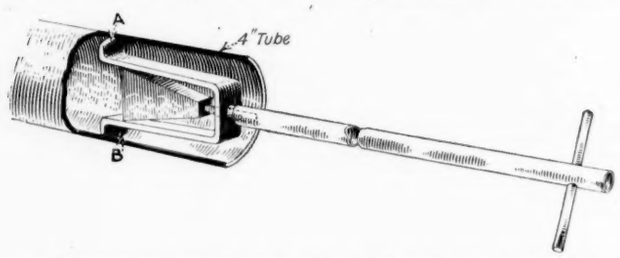
ings should contain 75 per cent. of coal that will pass through a 1½-in. but not through a 1-in. screen, not more than 20 per cent. through a ½-in. screen, etc., so that coal of lower market and heating value could be purchased at a lower price, instead of, as at present, including at one price any coal that is capable of passing through the specified screen.

As long as the purchaser accepts all sizes of screenings, just so long will he be given them, and the remedy is to specify the sizes that are acceptable. A little attention to this matter will help toward a more uniform quality and tend to encourage briquetting or the development of coal-dust burners for its better utilization.

Oak Park, Ill. LEONARD KENNEDY.

Home-Made Tube or Flue Scraper

There are plenty of good tube and flue scrapers on the market, but some of us have to make our own. Take an old 14-in. flat file, cut off the tang and draw down each



ADJUSTABLE TUBE SCRAPER MADE FROM OLD FILE

end and bend at right angles. Drill or punch a ⅝-in. hole through the middle, then bend to the shape shown. Grind the cutting edges *A* and *B* to the angle desired. A wedge for adjusting the size, to make the scraper fit the tube, with the round part threaded for ⅝-in. nuts and also to attach the handle which can easily be made of pipe. When the scraper gets dull, it has to be ground and the wedge adjusted again. H. C. WILLIAMS.

Concord, N. H.

The Engineer's Right to Recognition

I was surprised to read in the Foreword in the issue of Nov. 14, that an engineer 45 years old is thinking of quitting because he cannot get out of the $150 class. Just think of it, 25 years in the business! Whose fault is it? Surely not the employer's—if an engineer with a $400 library is not able to convince his employer that he is worth more money. Maybe he has outgrown the plant. Such cases are not rare, as an engineer can easily outgrow his plant. I have charge of 11 plants, and frequently I have to move an engineer to a larger plant because he has outgrown the one in which he is working and by his faithful performance of duty has shown that he is entitled to somthing better and bigger.

I am 47 years old and just starting to be an engineer. I am still learning and cannot agree that the profession is dying out. It is just waking up and coming to the front and is calling for high-grade men—not particularly for technical men, but for engineers who can deliver the goods.

I hope that the brother engineer will not quit the business, but will be able to show that he is entitled to be recognized both financially and socially.

Tulsa, Okla. B. MEYER.

Removing an Old Foundation

We had a job of removing an old engine foundation that was made of concrete of a good rich mixture and extended 6 ft. below the floor level. Two regular concrete workers agreed to do the job, but after they had worked with drills, stone hammers and chisels for half a day and had only about a bushel of chips, they said the thing was too big for them and quit.

Three men were then hired by the day to see what could be done. They tried drilling and blasting, but that only drove a few chips loose and out through the roof. The blasting would not do, but it furnished us a clue to success. We noticed that holes drilled close to the edge could be split out with a chisel, so we had a bar 1¼x14 in. drawn to a point and tempered. One man held the chisel with a holder about 4 ft. long and two with heavy sledges soon reduced the foundation to pieces that could be handled easily. R. C. WILLEY.

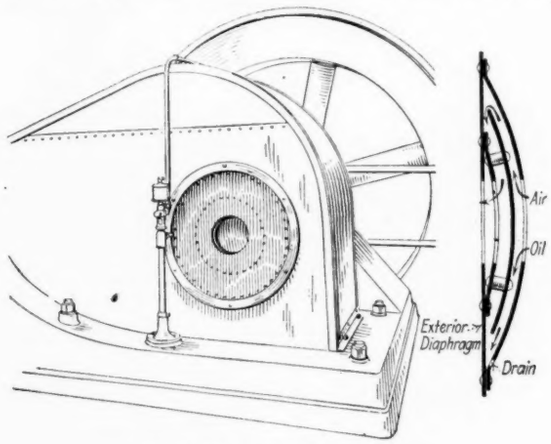
Lamoni, Iowa.

A Satisfactory Oil Guard

In a power plant with high-speed engines the cranks of which were inclosed in sheet-iron cases, a 20-in. opening was left opposite the forward crank center to give access to the rod end for keying, etc.

To keep the oil from splashing out on the floor, the engine builders covered the opening with a fine-mesh screen.

As an oil guard it was an unsatisfactory arrangement, as the pulsations of air acting on the screen distorted it, and as it flapped back and forth oil was thrown off, much



DETAILS OF OIL GUARD

of which went to the floor. Transverse braces were put on to stiffen it, but with no great success. After some thought a modified form of exhaust head was made of No. 16 sheet iron and put over the opening as an experiment by one of the mechanics in the plant.

The sketch shows how it was made and attached to the case, and the certainty with which it stopped all throwing of oil and still gave perfect ventilation was highly satisfactory. F. L. JOHNSON.

New York City.

Vegetable Oils Will Wash Out of fabrics, but mineral oils will not.

Oil Does Not Wear Out, but does need treatment to cleanse and purify it.

Saving Wear on a Fire Pump

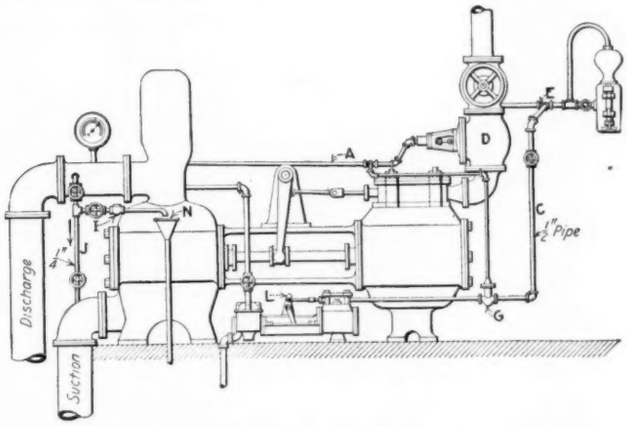
It is necessary to keep pressure at all times on the fire mains running through a large tie and timber yard. The wear and tear on the rods and packing of the fire pump, due to intermittent operation, is quite considerable, so I used the method shown in the illustration to overcome the trouble.

The fire pump, an 18x10x12-in. duplex, would start about every ten minutes to make up the loss from leakage and boost the pressure until the automatic governor shut off the steam. I placed a 3x2x3-in. duplex pump, shown at *L*, and connected the ½-in. steam line to it from the lubricator line at *E*, coming out from a tee horizontally, below the throttle valve and above the governor *D*. A governor was also placed on the ½-in. steam line at *G* and the water connection made from the line *A* leading to the large governor.

When the large pump was running, the small one stopped, as its throttle had to be only partly open to give enough steam. When the large governor shut off the steam to the fire pump, the small pump started up and boosted the pressure up on the line until its own governor slowed it down to just speed enough to take care of the leaks (about 20 strokes per minute).

The large governor was set to shut off at 75 and the small one at 85 lb. If a fire plug was opened, the pressure would drop to 75 lb. and the large pump would start to work.

The one lubricator took care of both pumps, as the oil would go with the steam. I found that, owing to packing and foot-valve leakage, the large pump would require



SMALL PUMP USED TO MAKE UP FOR LEAKAGE IN FIRE LINE

priming after standing some time; so I connected ¼-in. piping, as shown at *J*, between the discharge and suction pipes and from a tee to the check valve *I* and then to the overflow. With the pump standing, the water from the discharge line kept the suction line full and would overflow at *N* without accumulating pressure in the suction line. When the fire pump was running, the check valve would close and prevent air entering the suction.

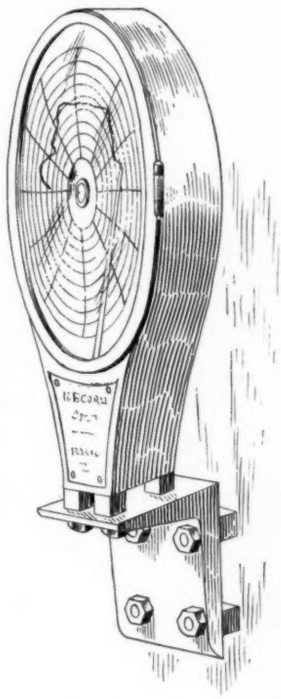
The house in which the fire pump is located is about 200 ft. from the main power building and has no regular attendant, but a pressure gage on the fire main in the engine room enables the engineer to see that the pressure is on.

CHARLES A. PHILLIPS.

Chrome, N. J.

Rubber Pads Reduce Vibration

We had a recording thermometer installed on a drying kiln to register the temperature, the thermometer being set upon a bracket fastened to the wall of the kiln. The vibration set up by the engines and other machinery caused the pen arm on the thermometer to vibrate to the extent of several degrees, but its location could not be changed. We then hit upon the idea of some sort of a shock absorber to take up a part of the vibration. Spring washers did not improve the situation, probably because they were not resilient enough. Rubber was then suggested, and a number of blocks about 1 in. square of soft erasing rubber were secured from a stationer and placed under the base of the recorder. This improved things to some extent, and others were placed between the wall of the kiln and the bracket, as shown in the illustration. This proved to be the solution, as the vibration of the pen has been entirely removed. We found, however, that the rubber became less pliable after several months' use, but it is inexpensive and easily replaced and is therefore not a serious objection.



SHOCK ABSORBERS UNDER THERMOMETER

M. A. SALLER.

Philadelphia, Penn.

Two Chief Engineers Contrasted

In one plant the chief, who is a good fellow and no "grouch," is well liked by the men, for he is kindly and considerate, but he is entirely devoid of a sense of humor. He seldom laughs, and it annoys him to see a bunch of fellows laughing and joking, as he considers it childish. Although the work around the plant is done right, still one gets a feeling of depression there.

In another plant the chief, also a good fellow who takes his work seriously, often has a good laugh about one thing or another, takes trouble with a smile and when there is an idle spell goes among the men and either tells them a good, clean, humorous yarn or listens to one (he will not stand for smutty ones); so that his men think of him as a personal friend as well as "chief," all are his faithful friends and will at any time do double duty without a kick. The men in this plant often stand around for a time comparing notes and joking, while in the former plant they all leave for home sharp at quitting time.

But supposing that each man gets the work done equally well; work is not everything in this life, joy in being alive and happy counts for a lot. Work done under pleasing conditions is not half so irksome as if done as a compulsory duty only.

JAMES E. NOBLE.

Kingston, Ont., Canada.

To Reduce Lubrication Cost

The question of cylinder lubrication according to my experience settles down more to the method in which the lubricant is introduced into the cylinder than to the quality or quantity fed. There seems to be a certain amount of oil required regardless of the quality.

The apparatus shown in Fig. 1 is used on the high-pressure cylinders of a 22, 40 & 60x52-in. triple, Corliss-

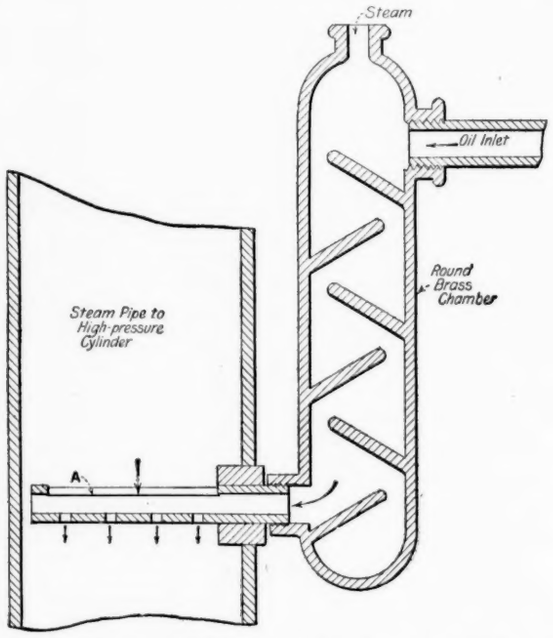


FIG. 1. OIL EMULSIFYING CHAMBER AND FEED PIPE

gear, pumping engine using steam at 200 lb. gage and no superheat. The function of the brass chamber is to mix oil and condensate together, forming an emulsion, which flows out into pipe A. This pipe is slotted on

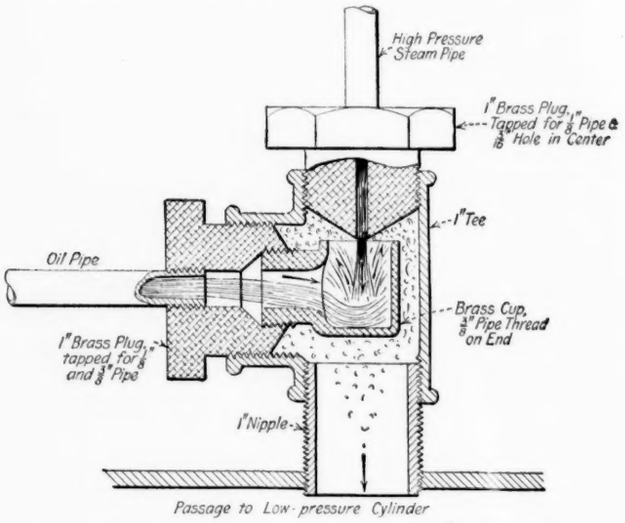

High Pressure Steam Pipe
1" Brass Plug, Tapped for 1/8" Pipe & 1/8" Hole in Center
1" Tee
Oil Pipe
Brass Cup, 3/8" Pipe Thread on End
1" Brass Plug, tapped for 1/8 and 3/8" Pipe
1" Nipple
Passage to Low-pressure Cylinder

FIG. 2. HIGH-PRESSURE STEAM TO VAPORIZE OIL

top and has four 1/8-inch holes drilled in the bottom. The emulsion drips through and is intimately mixed with the steam.

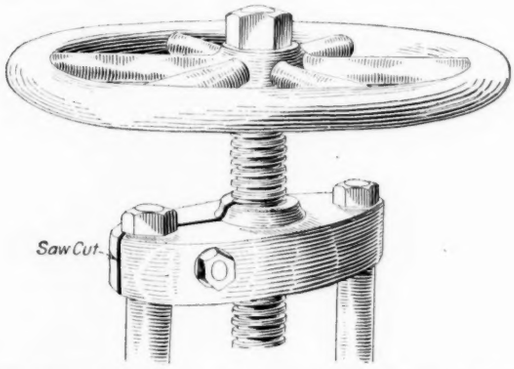
The apparatus shown in Fig. 2 is used on the intermediate and low-pressure cylinders. Essentially it is a brass cup into which the oil is pumped. A high-pressure steam jet impinges on the oil, breaking it up into a vapor which falls into the steam passages. The steam flowing to the intermediate and low-pressure cylinders is generally wet enough to emulsify the oil. The same quantity and quality of oil is fed to each cylinder, and as some oil must remain in the steam, it helps lubricate the next cylinder, which has greater surface. The cost is about 15 cents per cylinder per day of 24 hours.

The chamber shown in Fig. 1 was obtained from the Standard Oil Co., and that shown in Fig. 2 was designed by me from suggestions from the same source. No beneficial results were obtained by mixing graphite with the oil, as the quantity of oil fed could not be reduced. Fine results were, however, obtained with graphite in a case of trouble with a large exhaust valve (10x42-in.) which was badly scored and would cut and groan regardless of the amount of oil fed. It was cured of groaning and eventually took a polish by introducing dry graphite directly over it through the indicator cock. A dose of one ounce every two hours for about two weeks and after that about three doses a week did the good work.

Chicago, Ill. S. H. FARNSWORTH.

Freeing Threads on Valve Stems

In power plants there are valves that are used only once in a while, and when they are needed their stem threads will sometimes stick or work stiff. I had such a case recently, and in trying to open the valve, I twisted the stem off. To prevent a recurrence, I split one side of the yoke with a hacksaw and drilled it to receive a bolt, as shown in the illustration, putting in a strip of sheet



SLOTTED YOKE ON INFREQUENTLY USED VALVES

iron to fill the split when tightening up the bolt. The stem can easily be freed by slacking the bolt and striking the yoke a few blows, and the yoke is not weakened as the bolt takes away any strain there may be. For yokes that will not permit of splitting as shown, it is best to cut a slot in the shape of a keyway on one side of the stem through the threaded part so as to act as a cleaner for any dirt or grit. We have several valve stems fixed that way, and they work first-rate.

Concord, N. H. H. C. WILLIAMS.

The Sampling Pipe through which passes the flue gas collected for analysis should be placed in the most active part of the gas flow. A good way to tell that you have the pipe in the right place in the uptake at the damper on the boiler side is to move it in and out across the gas path, analyzing samples collected at each position; the point where the quality of the gas varies most widely in a given time is the correct place for the sampling pipe.

Inquiries of General Interest

Ammeter Reading on an Alternating-Current Circuit—Is there a greater current flowing through an ammeter indicating 100 amp. on a circuit of 0.50 power factor than when on a circuit having a power factor of 0.98? W. R.

The current passing through the instrument would be the same in either case. A wattmeter connected in the circuit would indicate approximately one-half as much on the 0.50-power-factor circuit as it would on the 0.98-power-factor circuit.

Reconnecting Induction Motor—What changes are necessary in the windings of a 3-phase 440-volt star-connected induction motor for it to operate on 220 volts? A. N.

If the starting conditions are not too severe, connecting the windings in delta will be satisfactory. With this connection the starting torque will be only about 75 per cent. of the 440-volt star connection, but the normal horsepower rating, efficiency and power factor will be practically unchanged.

Resultant of Three Resistances in Multiple—If a group of three resistances in multiple is connected between the line wires of a 100-volt circuit, the first having a resistance of 100 ohms, the second a resistance of 25 ohms and the third a resistance of 50 ohms, what would be the joint resistance of the three paths in multiple? M. S. H.

The joint resistance of the three paths in multiple would be the reciprocal of the sum of the reciprocals of the individual resistances as given by the expression,

$$R = \frac{1}{1/10 + 1/25 + 1/50} = 6.25 \text{ ohms}$$

Why a Fusible Plug Fuses—What causes a fusible plug to melt when it becomes uncovered by the water in a boiler? D. H.

While a fusible plug is submerged, it is kept cool by the rapid transfer of heat from the plug to the water of the boiler in supplying latent heat of evaporation to the water that is in contact with the fusible material of the plug. But when exposed only to steam, the transfer of heat is so slow that the fusible material quickly attains sufficient temperature to become fused.

Cost of Coal per Kilowatt-Hour—What would be the cost of coal per kilowatt-hour for a 100-kw. engine and generator where the actual economy is 5 lb. of coal per indicated horsepower-hour and the coal costs $7.50 per ton of 2000 lb.? R. C.

The output per indicated horsepower would depend on the mechanical efficiency of the engine and the efficiency of the generator, and the efficiencies will vary with the load. Assuming, for full load, that the mechanical efficiency of the engine is 90 per cent. and the efficiency of the generator is 92 per cent., the cost of coal would be $(7.50 \times 5) \div (2000 \times 0.90 \times 0.92 \times 0.746) = 3$c. per kw.-hr.

Test Pressure for Refrigeration System—What test pressure should be applied to the refrigeration and condensing coils of an ammonia compression system? T. J. S.

The testing as to tightness of pipes, joints and connections is generally made with an air-test pressure of 300 lb. per sq.in., by operating the compressor slowly without raising the temperature of the compressed air too much, as a high temperature might volatilize oil that has found its way into the system and convert it into a highly explosive hydrocarbon. Care should be taken, also, that there is no leakage between the discharge pipe and the high-pressure gage, as serious accidents have resulted from accumulations of enormous test pressures that have been improperly indicated by the gage.

Objections to Long Pump Suction Pipe—Why are long horizontal runs objectionable for pump suction pipes when raising water with a suction lift? R. C.

For a given pipe size and velocity of flow the frictional resistance to flow increases directly as the length of the pipe. Another objection is that the longer the suction pipe the more likely is it to become airbound. Under ordinary atmospheric conditions water contains about 2 per cent. of air in solution, and when the pressure is reduced the air will expand. Under a suction lift of 17 ft. the volume of the air expands to about 4 per cent. Besides cutting down the pump capacity, the air has time to become liberated from a large volume of water, and aggregations of bubbles form in the suction pipe, causing it to become airbound.

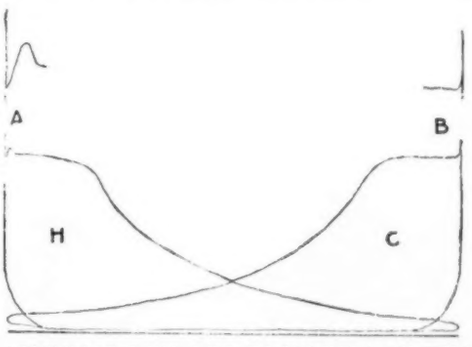
Pressure Exerted by Column of Water—What would be the pressure in pounds per square inch of a column of water 100 ft. high? E. L.

As the density of water varies with its temperature, the pressure exerted by a column of water depends on its temperature. Unless otherwise stated, the standard temperature 62 deg. F. is understood. A table of "Density and Volume of Water," by F. R. Low ("Power," Oct. 19, 1915, pp. 542-3), gives the density of water at 62 deg. F. as 62.3564 lb. per cu.ft., hence a column of water 1 ft. by 1 ft. and 100 ft. high at the temperature of 62 deg. F. would exert a pressure of $(1 \times 1 \times 100) \times 62.3564 = 6235.64$ lb. per sq.ft., which would be equivalent to $6235.64 \div 144 = 43.3$ lb. per sq.in. In ordinary calculations the pressure per foot of head or height usually is assumed as 0.433 lb. per sq.in.

Percentage of Heat Utilized by Engine—With an evaporative economy of 8 lb. of water per pound of fuel, if the fuel contains 10,000 B.t.u. per pound, what percentage of the energy contained in the fuel required for generating steam is utilized by an engine that consumes 25 lb. of steam per indicated horsepower-hour? G. N.

One mean B.t.u. is equal to 777.52 standard foot-pounds, and for purposes of ordinary computations a B.t.u. is assumed to be equivalent to 778 ft.-lb. Therefore the energy contained in one pound of the fuel would be $10,000 \times 778 = 7,780,000$ ft.-lb., and with an evaporative economy of 8 lb. of water per pound of fuel and a steam consumption of 25 lb. of water per indicated horsepower-hour the expenditure of heat energy would be $(7,780,000 \times 25) \div 8 = 24,312,500$ ft.-lb. per i.hp.-hr. One i.hp.-hr. would be a development of $33,000 \times 60 = 1,980,000$ ft.-lb. Hence the percentage utilized would be $(1,980,000 \times 100) \div 24,312,500 = 8.14$ per cent.

False Admission Line on Indicator Diagram—The accompanying pair of indicator diagrams taken with an 80-lb. spring are from a 16x30-in. Corliss engine running 120 r.p.m. What causes the pencil to rise at the admission above the steam lines of the diagrams, as shown at A and B? J. D. B.



FALSE ADMISSION LINE DUE TO INERTIA OF INDICATOR

The sudden rise and fall of the lines at A and B are due to excessive motion and ricocheting of the indicator spring and pencil motion from sudden admission of steam and inertia of the indicator.

Direct and Indirect Rockers on Duplex Pump—Why is the steam valve of one side of an ordinary duplex steam pump operated by a direct rocker and the other side by an indirect rocker? R. C.

For beginning a stroke on either side of the pump, each slide valve must be moved in the direction of motion that is to be taken by its piston, and after completion of a piston stroke the valve must be moved in the opposite direction. If both sides had direct rocker connections, they would operate as one and each could make but a single stroke, as there would be no reversal of the valves. By having a direct rocker connection from one of the sides to operate the valve of the other side, combined with lost motion, the valve of the second side is opened and the second side begins to follow the first side just prior to the completion of the stroke of the first side; then, by means of an indirect rocker connected to the second side, combined with lost motion, the valve of the first side is reversed before the stroke of the second side has been completed.

Outlook for Adoption of Metric System

Owing to the failure of the chairman of the Committee on Coinage, Weights and Measures—to which my bill for the adoption of the metric system by the United States has been referred—to call any meetings of his committee to consider this matter and owing, also, to the apparent lack of inclination of the committee as a whole to consider this matter, I fear that the people of the United States will be forced to wait until the next session of Congress before securing a modern, serviceable and convenient system of weights and measures.

This was the statement issued by Representative Dillon, father of the Dillon Metric System Bill, when asked recently what was the outlook for the adoption of the metric system by Congress. Mr. Dillon continued:

No crystallized opposition to this bill, which has the unqualified support of all Government bureaus and divisions which would be affected by it, has appeared, but this fact, instead of making the task of passing the bill easy, really renders it much harder. You can fight opposition and meet fire with fire, but it is very difficult and extremely discouraging to be faced merely by a disinclination to consider the subject at hand, particularly when the question is one which so vitally concerns the commercial welfare of the country. Our present system of weights and measures is antiquated and out of accord with the spirit of commerce with the rest of the world, and as it is manifestly necessary that we engage in foreign commerce, it is likewise essential that we do business as our customers are accustomed to do it—and not merely in our own narrow way. This necessitates the use of two systems of weights and measures—the one which we are now using and that which is in vogue in the majority of foreign nations.

If there were any reasonable doubt as to which is the better system, the question might be open to argument, but scientists and men of commerce alike approve the metric system in contradistinction to our method, and the consequence is that we find ourselves competing with the other great commercial nations of the world at a distinct disadvantage. It is my belief, however, that the opening of the Sixty-fifth Congress will see a shake-up in a number of the more important committees and that it will be possible to secure some definite action on this bill within a comparatively short time. In the meantime I shall content myself with the collection of all available material in support of this measure and the securing of indorsements for it from as many prominent Government officials and men of business as possible, so that the provision for the adoption of the metric system ought to be a relatively simple matter. I am certain that it would be so if the people of the nation realized the immense advantages, commercial and otherwise, of this easily learned and very convenient table.

Mr. Dillon's bill, which is now in charge of the Committee of Coinage, Weights and Measures, of which Representative Ashbrook is chairman, provides that:

The weights and measures of the metric system shall be the sole standard of weights and measures in the United States on and after July, 1920: Provided, that in the meantime such metric system shall be permissive.

That all equivalents between the units of the metric system and the system now in common use throughout the United States shall be calculated from the fundamental relation, one meter being equivalent to 39.37 in. and one kilogram being equivalent to 2.204622 avoirdupois-pounds.

That the Director of the Bureau of Standards, with the approval of the Secretary of Commerce, shall prescribe rules and regulations for the carrying out of this act and shall prepare and promulgate tables based upon the fundamental relation heretofore mentioned, showing the equivalents of the weights and measures of the metric system to those of the system in common use in the United States.

That any person, corporation, company, society or association who shall use or offer and attempt to use in any industrial or commercial transaction in the sale or purchase of any commodity any other weights and measures than those of the metric system on and after July 1, 1924, shall be guilty of a misdemeanor and, upon conviction thereof in any court of competent jurisdiction, shall be punished by a fine of not more than $500 or by imprisonment for not more than three months, or by both such fine and imprisonment.

After a complete and sweeping investigation of the subject of the adoption of the metric system with relation to foreign commerce, Dr. Samuel W. Stratton, Director of the Bureau of Standards of the Department of Commerce, has stated emphatically that he is in favor of the system in vogue abroad and that he will gladly assist Representative Dillon in inaugurating the system in this country. He says:

The reasonable use of the metric system to the extent demanded by American export business, will break down three serious obstacles to trade extension in Latin America, where the metric system has been adopted and is now in use. These three obstacles which will be largely removed are: The nonusability of nonmetric products in metric countries; ignorance of foreign market conditions, opportunities and statistics which, to the nonmetric business man, are not well known, and the ignorance in those foreign countries as to our available products and their units and prices, owing chiefly to inability on the part of the great mass of possible buyers to understand our measures.

The extent to which the metric system is used in foreign countries is not realized even by well-informed manufacturers. Its use in science and medicine is almost world-wide, even China, a country of 400,000,000 people, being now in the process of adopting this system. After an extensive investigation of the subject, the weights and measures commission of China reported that the metric system should eventually be adopted.

With the metric system adopted in continental Europe, Latin America and China our isolation with respect to units of weights and measures becomes steadily more complete. Already our liquid and dry measures are unique among the nations of the world, differing even from those of England. It is therefore a most serious question whether we can afford to continue a system out of harmony with the rest of the world. Unification of weights and measures is quite as important a matter as the universal systems of longitude and time. Such unification has been accomplished in scientific work the world over and in 34 countries for other purposes. The latter is sufficient evidence of its feasibility.

Commerce, technology and science have, on account of their international character, availed themselves of the advantages of the metric system more than manufacturing, which is local and, unlike exporting, not in direct touch with world markets. Hence science and commerce with their world-wide outlooks, should be the advisers of industry, and their conclusion is that the first principle is to supply what the customer needs and that international business requires international weights and measures.

There is also a deeper point of view which should not be ignored. In addition to great incidental advantages in the use of the international metric system—such as easier selling, greater satisfaction to buyers and proximate profits—there are additional far-reaching gains which cannot be overestimated.

Above all, the effect upon the comity of nations in having a common language of measurement would be to add one more bond of mutual understanding to the forces tending toward permanent universal international peace. When one takes all these matters into consideration, it will be seen that the adoption of the metric system by the United States is a matter the importance of which can hardly be overestimated, and the sooner we take advantage of the simplicities of this system the better for our commercial, industrial and international life.

Standard Dampers, Breechings and Stacks

Of the various suggestions submitted by the Standards Committee of the Smoke Prevention Association at the last convention in St. Louis, the following are recommendations for dampers, breechings and stacks for high-pressure steam-power plants, offered by Osborn Monnett, formerly chief smoke inspector of Chicago and now with the American Radiator Co.

Dampers—For horizontal return-tubular boilers the dampers shall occupy the full width of the available opening and have a free area 25 per cent. in excess of the combined area of the tubes. No type of damper plate that restricts the opening shall be used. In water-tube boilers a free opening of one-quarter the grate surface shall be provided, and the dampers when wide open shall hang in such a manner as not to obstruct the movement of the gases. It is recommended that no damper be placed in the main breeching.

Breechings—These shall be as short and direct as possible, preferably having a direct run without turns into the stack. No right-angle turns shall be used. If necessary to install a breeching with turns, the latter shall be in long-sweep bends with a radius on the center of the turn of not less than the diameter or width of the breeching. The breeching shall not dip below the horizontal, but should have an easy slope upward to the stack. The connection from the breeching to the stack is preferably at an angle of 45 deg. Breechings should not be constructed of brick or other porous material subject to leakage. Breechings made of steel plate should have angle irons on the outside and have no projections on the inside to resist the flow of the gases. Lagging should be on the outside, where its condition can be readily inspected, where repairs can be made without interrupting the operation of the plant and where loose pieces will not obstruct the flow of the gases. Clean-out doors should be provided at convenient points for the removal of accumulations of soot.

Area—For water-tube boilers the area of the breeching shall not be less than 22 per cent. of the total area of the grate surface served, or a ratio of breeching to grate surface of 1 to 4½. For horizontal return-tubular boilers the area of the breeching shall be 25 per cent. in excess of the total area through tubes. Breechings shall preferably have a round or square section. In case of rectangular shape, one side shall not be more than one-third greater than the other.

Stacks—These should be located so as to give the most favorable run of breeching possible. Steel stacks should be lined for a height equal to ten times their diameter. For water-tube boilers the free area of the stack at the smallest point should be not less than one-fifth the area of the total connected grate surface, where the stack is less than 150 ft. high. Where the stack is over 150 ft. high, the area shall be not less than one-sixth the grate surface. For horizontal return-tubular boilers the stacks should have an area in free opening at the smallest point 25 per cent. in excess of the combined area of the tubes served.

A good formula for calculating the draft available from a certain height of stack is

$$D = 0.52HP\left(\frac{1}{T} - \frac{1}{T_1}\right)$$

in which

D = Draft in inches of water;

H = Height of the stack above the grate in feet;

P = Atmospheric pressure in pounds per square inch;
T = Atmospheric temperature, absolute;
T_1 = Absolute temperature of the stack gases.

For convenience the values of the product $0.52 \times P \left(\frac{1}{T} - \frac{1}{T_1}\right) = K$ have been calculated for a number of different flue-gas temperatures at sea level and 60 deg. F. atmospheric temperature. The formula becomes D = KH, the values of K being as follows:

Temp. Stack Gas	K	Temp. Stack Gas	K	Temp. Stack Gas	K
750	0.0084	600	0.0075	450	0.0063
700	0.0081	550	0.0071	400	0.0058
650	0.0078	500	0.0067	350	0.0053

To provide for frictional resistance, 0.001 should be subtracted from the constant K. Let K — 0.001 = U, giving the ultimate constant U. Therefore to find the available draft in a stack of given height, multiply the height of the stack by the constant corresponding to the flue-gas temperature; or D = HU.

To find the height of stack above the grate necessary to make available a given draft at a given flue temperature, divide the draft required by the constant corresponding to the temperature; or $H = \frac{D}{U}$.

Present Status of Water-Power Legislation

Unless some unforeseen development provides for the sudden and expeditious release of the legislative jam into which the Senate has worked itself, there is little likelihood of any definite action being taken at this session with respect to the two water-power bills now in conference. This is the view taken by both Senator Shields and Senator Myers, who, respectively, are engineering these two bills through the upper House of Congress. In discussing this matter recently, Senator Shields said:

I regret to state that I see little hope for any action on the Shields Water Power bill at this session of Congress. The men who are supporting this measure had hoped, last year, to be able to secure some definite action on this most important measure, but at present there appears to be little likelihood of our securing a hearing on this bill before Mar. 4. The House and the Senate are both tied up with a multitude of other matters, and unless something unforeseen occurs to relieve this congestion and permit this bill to come out of conference, I fear that it will not be considered before the close of the Sixty-fourth Congress.

While the matters which are now engaging the attention of Congress are, it must be admitted, of great importance, the question of the use of the great American water-power resources is also of vital import to the people of the United States, and it is therefore to be regretted that definite action on this matter will probably have to await the next session. My information, however, is to the effect that no decisive step can be expected during the present short session of Congress, but the matter will be taken up and vigorously pushed as soon as the Sixty-fifth Congress opens.

In support of the Ferris bill, which is also expected to die of inanition at the close of this session, but which will also be reintroduced as soon as Congress meets again, Secretary of the Interior Lane recently stated:

The bill to promote hydro-electric development on public lands—known as the Ferris bill—was called for by the fact that existing legislation permits only a revocable permit to be granted for such use, and this was regarded by engineers and financiers as too tentative and hazardous a tenure where millions of money were needed for the installation of the necessary plant.

The Ferris bill meets this difficulty by proposing a lease of these lands for a definite term of 50 years. At the end of this period, if the plant has been so managed as to best serve the country, there would be no reason why the holding company should not have a new lease. If it has not been so managed, the plant should be bought at its value by whoever the new lessee might be or by those who took over the lands on which it was situated—the state, for instance. In other countries the plant is generally made to revert to the government at the end of the period, without cost; and when it is realized that by establishing an amortization fund of ½ per cent. each year, the full expenditure can be refunded in 50 years, the difficulty of caring for the investment should not be insuperable.

The state owns the water, it is said, and therefore should command the right to the use of the land. This line of reasoning leads to an impasse. We are not considering rights, but what course is wise. Quite plainly the state cannot command the use of the land, and it is not proposed that the nation shall command the use of the water, for no one can have the land at all unless he first gain the right to use the water from the state. We have given no other land to the state, except for the sustaining of schools and colleges or for reclamation. If a state wishes coal land it must buy it. The traditional policy of the Government has been to deal directly with the people in disposing of their domain.

The fear is expressed that by the imposition of charges for the use of the land, an undue and unjust burden will be cast upon the people. The basis of this fear has not been discovered. Congress may, if it so desires, fix absolutely the charge that shall be made, and if this were done, the charge should be so low as to make the added burden upon the consumer, if any, an infinitestimal one, perhaps first a free period when no charge would be made, then one-tenth of a mill per kilowatt-hour for a certain period and two-tenths of a mill later.

I am sorry that there appears to be little chance of this bill passing this Congress, for it is a measure of vital importance and tremendous interest to the peeople of the Nation.

PERSONALS

John J. Braun, chief engineer of the New York Consolidated Card Co., has been appointed assistant factory manager of the Long Island City plant.

George Lewis, formerly chief engineer of the Bradstreet Building, has accepted a similar position with the New York Consolidated Card Co., Long Island City, N. Y.

Joseph R. Greenwood, formerly general manager of the Ballwood Co., is now associated with the office of Charles H. Higgins, architect-engineer, 30 Church St., New York City.

E. B. Lupton, for 18 years chief engineer of the Industry Mill, Paterson, N. J., is now connected with the Montclair Water Co. as chief engineer of the pumping station at Little Falls, N. J.

H. O. Swoboda has been retained by the City Council of Pittsburgh, Penn., as consulting engineer for the purpose of making a preliminary investigation of the street-lighting situation in Pittsburgh at the present time.

George C. Hicks, Jr., vice-president and engineer of the P. H. & F. M. Roots Co., of Connersville, Ind., for the past 15 years, announces his retirement from the company on Jan. 1, 1917. Mr. Hicks will act as consulting engineer for the company for a short time. Before taking up work again, he expects to take a six months' vacation.

OBITUARY

Joseph H. Neemes, of Neemes Bros., Troy, N. Y., died on Dec. 29, after a year's illness.

James Maclay, a member of the McNab & Harlin Manufacturing Co., brass and iron manufacturers, whose plant in Paterson, N. J., is one of the largest of its kind in New Jersey, died Thursday at his home in Paterson after an illness of several weeks, aged 83 years. He is survived by his widow, one daughter and one son.

ENGINEERING AFFAIRS

The American Society of Heating and Ventilating Engineers will hold its annual meeting at the Engineering Societies' Building, New York, Jan. 16 to 18.

The Association of Iron and Steel Electrical Engineers will hold its regular monthly meeting in Pittsburgh, Penn., on Jan. 20, with headquarters at the Fort Pitt Hotel.

The National Marine Engineers' Beneficial Association of the U. S. A. will hold its forty-second annual convention at Washington, D. C., on Jan. 22, and it promises to be the most important in the history of the organization.

TRADE CATALOGS

Rubber Hose. Peerless Rubber Manufacturing Co., 31 Warren St., New York. Catalog; pp. 48; 6x9 in.; illustrated.

Storage Battery Trucks for Industrial Plants. The Jeffrey Manufacturing Co., 932 North Fourth St., Columbus, Ohio. Bulletin No. 200; pp. 8; 6x9 in.; illustrated.

Lagonda Locomotive Arch Tube Cleaners. The Lagonda Manufacturing Co., Springfield, Ohio. Catalog W-3; pp. 12; 6x9 in.; illustrated. This discusses the formation of scale in arch tubes and shows construction of cleaners.

Spraco Equipment for Washing and Cooling Air. Spray Engineering Co., 93 Federal St., Boston, Mass. Bulletin No. 250; pp. 16; 8x11 in. This is well illustrated and describes equipment especially applicable for steam-turbine generators and other electrical machinery.

Humidity and Temperature Regulating Devices. Carrier Engineering Corp., 39 Cortlandt St., New York. Bulletin No. 102; pp. 48; 6x9 in.; illustrated. Explains how a system of control is dependent upon such factors as number and size of rooms, their contents, arrangement of machinery, effect of air currents, etc.

THE COAL MARKET

Boston—Current quotations per gross ton delivered alongside Boston points are as follows:

ANTHRACITE

	Circular		Individual	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago
Buckwheat	$3.60	$3.10	$6.00@6 50	$3.00@3.50
Rice	3.10	2.50	5.50@5.75	2.60@3.00
Boiler	2.95	....	5.00@5.25	.....
Barley	2.85	2.25	4.20@4.60	2.45@2.60

BITUMINOUS

Prices per gross ton for Boston delivery:

	F.o.b. Mines		Alongside Boston	
	All-Rail Rate $2.60 to Boston		Water Coal	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago
Clearfields	$4.75@5.60	$2.50@3.25	$8.00@8.50	.....
Cambrias and Somersets	5.00@6.00	2.85@3.25	8.25@8.75	.....
	F.o.b. Hampton Roads		On Cars, Boston	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago
Pocahontas and New River	$6 75@7.25	$2.85	$8.75@9.50	$6.00@6.25

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports are as follows:

ANTHRACITE

	Circular		Individual	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago
Buckwheat	$2.75	$2.75	$6.25@6.50	$3.20@3.45
Rice	2.20	2.25	4.75@5.25	2.95@3.20
Barley	1.95	1.75	3.25@3.50	2.20@2.45

Quotations at the upper ports are about 5c. higher.

BITUMINOUS

	South Amboy		Port Reading	Mine Price	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	Jan. 13, 1917	One Year Ago
Clearfield	$7.25@7.75	$4.15@4 55	$7.25@7.75	$5.50@5.75	$2.60@3.00
South Forks	7.25@7.75	4.30@4.55	7.25@7.75	5.50@5.75	2.75@3.00
Nanty Glo	7.25@7.75	4 30@4.55	7.25@7.75	5.50@5.75	2.75@3.00
Somerset	7.25@7.75	4.15@4.40	7.25@7.75	5.25@5.50	2.75@3.00
Quehamoning	7.25@7.75	4 15@4.40	7.25@7.75	5.25@5.50	2.75@3.00

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago
Buckwheat	$2.00	$1.55	$2.90	$2.30
Rice	1.25	.90	2.15	1.80
Boiler	1.10	....	2.00	....
Barley	1.00	.55	1.90	1.30

Birmingham—Current prices per net ton f.o.b. mines:

	Mine-Run	Washed Mine-Run	Washed Nut
Pratt	$3.00	$4.50	$4.50
Big Seam	2.75	$3.75@4.25	$3.75@4.25
Black Creek	3.50	4.50	4.50
Carbon Hill	2.75	4.00	4.00
Cahaba	3 50	4.50	4.50

Pittsburgh—Price of steam coal per net ton f.o.b. mine, Pittsburgh district:

	Jan. 13, 1917	One Year Ago
Slack	$3.85@4.00	$1.25@1.50
Mine-run	4.00@4.25	1.25@1.50
¾-in.	4.00@4.25	1.35@1.60

Add 40c. per ton for freight charge to Pittsburgh.

Chicago—Current prices per net ton f.o.b. mines:

	Springfield	Clinton and Sullivan Cos.
Steam lump	$3 50@3.75	$3.50@3.75
Egg	3.50@3.75	3.50@4.00
Nut	3.25@3.50	3.25@3.75
Mine-run	3.50@3.75	3.50@3 75
Screenings	3.50@3.75	3.50@3.75

	Williamson and Franklin Counties	Saline and Harrisburg	West Virginia Smokeless
Lump	$3.75@4.00	$3.75@4.00	$5.00@5.50
Egg	3.75@4.00	3.75@4.00	5.00@5.50
Nut	.....	3.75@4 00	.....
No. 1 nut	3.75@4.00	.....	.....
No. 2 nut	3.75@4.00	.....	.....
No. 3 nut	3.75@4.00	.....	.....
No. 1 washed	3.75@4.00	.....	.....
No. 2 washed	3.50@3.75	.....	.....
Mine-run	3.50@3.75	3.50@3.75	4.75@5.25
Screenings	3.50@3.75	3.50@3.75	.....

Hocking lump, $4; splint lump, $4.25.

St. Louis—Price per net ton f.o.b. mine:

	Williamson and Franklin Counties		Mt. Olive and Staunton		Standard	
	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago	Jan. 13, 1917	One Year Ago
6-in. lump	$3.25@3.50	$1.60@1.75	$3.25@3.50	$1.25	$2.35@2.75	$1.10@1.15
2-in. lump	.....	1.35@1.50	.....	1.15	2.25@2 50	.95@1.00
Steam egg	.....	.....	3.25	....	2.25@2 50	.....
Mine-run	3.00@3.25	1.10@1.15	3.00	1.00@1.05	2.00@2.25	.90@ .95
No. 1 nut	.....	1.25@1.35	.....	....	.....	.95@1.00
2-in. screenings	3.50	.85@ .90	2.75@3.00	.75@ .80	2.25@2.50	.75@ .80
No. 5 washed	3.25@3.50	.85@ .90	.....	.75@ .80	2.50	.75@ .80

Williamson-Franklin rate St. Louis, 72½c.; other rates, 57½c.

6-in. lump	$3 50	$1.50	$3.50	$1.25	$3.50	$1.10@1.15

PROPOSED CONSTRUCTION

Alta., Drumheller—The Northwestern Engineering and Supply Co., Calgary, has been granted a franchise to operate an electric-light and power plant in Drumheller.

Ariz., Nogales—The International Gas Co., Nogales, plans to extend its transmission lines to Cananea and other points in northern Sonora, Mexico. E. Roberts, Nogales, is chief engineer.

Ariz., Prescott—The Arizona Power Co. plans to build an additional electric-power station of 10,000-hp. capacity to supply the mines in the Jerome district with energy.

Ariz., Wilcox—N. McMillan has been granted a franchise to install and operate an electric-light plant in Wilcox.

Ark., Earl—The electric-light plant of the Earl Light, Power and Ice Co., recently destroyed by fire, will be rebuilt.

Calif., Chico—D. Murphy has submitted a proposition to the Business Men's Association to install a municipal electric-light plant. Estimated cost, $750,000.

Ga., Summersville—The local business men of Summersville plan to organize a company to install and operate an electric-light plant. Estimated cost, $5000. C. C. Cleghorn and S. C. Martin are interested.

Iowa, Grinnel—The Iowa Light, Heat and Power Co. has applied to the State Railroad Commission for permission to build an electric transmission line in Carroll County.

Iowa, Marne—The city plans to install an electric-light plant.

Iowa, Toronto—An appropriation has been made by the City Council for the installation of an electric-lighting system.

Mich., Ann Arbor—Bids will soon be received by the Detroit Edison Co., Washington and State St., Detroit, for a hydro-electric power plant on the Huron River. Estimated cost, $140,000. G. S. Williams, Cornwell Building, is engineer.

Minn., Faribault—The citizens plan to install a municipal electric-light plant.

Minn., Pine River—The Pine River Lighting Co., Pine River, plans to extend its transmission lines to Walker.

Mont., Libby—The Libby Water-Works, Electric Light and Power Co. plans to install a 125-hp. engine. Estimated cost, $10,000.

Neb., Winside—The city plans to hold an election to vote on $7500 bonds to install an electric-light system.

Nev., Austin—Berg & Rice, Austin, has been granted a franchise to install an electric-light plant.

N. J., Elizabeth—Plans are being considered by the City Council for the installation of an electric-light plant.

N. J., Jersey City—The Board of Freeholders of Hudson County plans to enlarge the electric-light plant in the court house to furnish service to all the county buildings and lighting along the county roads. Address County Clerk, Jersey City.

N. Y., Edmeston—Plans are being considered by the city for the installation of an electric-lighting system.

N. Y., Lockport—A committee has been appointed by the city to make investigations with a view to installing an electric-light plant.

N. D., Courtmey—The city plans to call an election to vote on bonds to install an electric-light plant.

Ohio, Circleville—Bids will soon be received by the Weill Furniture Co. for a heating plant. J. M. Weill is manager. J. Goldsmith, 72 Wheeler Building, Columbus, is architect.

Ohio, Massillon—The Northern Ohio Traction and Light Co., Akron, plans to construct a substation. R. Harter, Akron, is purchasing agent.

Okla., Crescent—Plans are being considered by the city for the installation of an electric-light plant.

Okla., Crowder—The city plans to install an electric-light plant.

Okla., Duke—The city plans to install an electric-light plant.

Okla., Mooreland—Bonds for $10,000 have been voted by the city for the installation of an electric-light system.

Okla., Wewoka—The city plans to call an election to vote on $8000 bonds to improve and extend the electric-light plant.

Ont., Hepworth—The citizens voted in favor of a by-law authorizing the Hepworth Light, Heat and Power Co. to install a distributing system.

Ont., Highgate—The city plans to install a hydro-electric plant.

Ont., Mimico—Bids will soon be received by the Provincial Hydro-Electric Power Commission, Toronto, for a 13,000-200-volt distributing system to supply electricity to Mimico, Mimico Hospital for Insane, New Toronto and a number of brick yards and other industries in the vicinity. F. A. Gaby is chief engineer.

Ont., Oil Springs—The City Council plans to spend $10,000 for the installation of a hydro-electric plant.

Penn., Philadelphia—An addition will be built to the boiler plant of the Hutlon Printing Co. on Frankford Ave.

Tex., Lubbock—The City Council voted bonds to install an electric-light plant.

Tex., Wills Point—The Wills Point Electric Light Co. has increased its capital stock from $10,000 to $20,000 and will improve its plant.

Wis., Black Earth—W. Meister is interested in a project to install an electric-light plant in Black Earth.

Wis., Janesville—The New Doty Manufacturing Co., 302 North Main St., has had plans prepared for a power plant and flume. J. C. Jacobson, 743 Security Building, Minneapolis, Minn., is engineer.